ABSTRACT

Title of Dissertation: SUSTAINING THE PACIFIC CARRIER AIR WAR: THE DEVELOPMENT OF U.S. NAVAL AVIATION MAINTENANCE AND THE ENLISTED AIRCRAFT TECHNICIAN IN WORLD WAR II

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The ability of the United States Navy to fight a protracted war throughout the Pacific Ocean in World War II was not solely the result of technology, tactics, or admiralship. Naval aviation maintenance played a major role in the U.S. victory over Japan. Naval aviation leadership throughout the period between World War I and World War II focused on the improvement of technology and tactics rather than training a new, and in the event of war, necessarily large cohort of enlisted personnel. Aircraft maintenance was an afterthought for much of the era because of the small number of carriers and aircraft. When the United States realized a two-ocean naval war was imminent and a drastic increase in the size of its aviation fleet was ordered, the navy was forced to reconsider its earlier practices and forge new polices and processes. The U.S. naval air war against Japan did not achieve sustained success until enough aircraft technicians were in place to support the doctrine of the Fast Carrier Task Force. The

United States Navy was not ready to fight a protracted war at sea until its carrier aircraft technicians were trained and in place.

The historiography of U.S. naval warfare in the modern era lacks any comprehensive study on the subject of naval aviation maintenance. This dissertation demonstrates the importance of considering all elements of the military institution, not just those that correspond to operational-battle history when studying the full dimensions of modern naval war in the age of the aircraft carrier. Recognizing the drastic institutional changes that accompanied an increase in maintenance personnel from less than 10,000 to nearly 250,000 over four years, a complete restructuring of the aviation navy's technical educational system, and the development of highly specialized skilled labor force on board the aircraft carrier are essential to creating a more complete historiography World War II naval warfare. Analyzing the effect that aircraft maintenance and the aircraft technician had on carrier warfare is an added layer to the complex study of war that should not be overlooked. Even in the era of modern-technologically advanced warfare, people still matter.

SUSTAINING THE PACIFIC CARRIER AIR WAR: THE DEVELOPMENT OF U.S. NAVAL AVIATION MAINTENANCE AND THE ENLISTED AIRCRAFT TECHNICIAN IN WORLD WAR II

by

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Introduction

Before the United States entered the Second World War, the might of the United States Navy's Pacific Fleet was characterized by the battleship rather than the aircraft carrier. Yet, after 7 December 1941, the realization that carrier-based naval aviation was a force to be reckoned with, soon challenged the hegemony battleship fleet. The Japanese attack on Pearl Harbor sank four of the U.S. Navy's eight battleships and the remaining four suffered catastrophic damage. The U.S. Pacific Fleet's order of battle was significantly altered in just a few hours. However, its carriers were all at sea that morning, far away from the devastation encircling Ford Island. The Japanese had demonstrated the awesome power of the aircraft carrier in a single morning. The United States was forced to accept that change was coming to its naval forces, whether it was prepared for it or not. The next four years would be a proving ground for the United States Navy's carrier aviation forces. Much more would be tested than just the will of the pilots and admirals. Aircraft maintenance and the training of its skilled labor force, the aircraft technicians, would become critical to the success of the navy in its war against the Japanese Navy. The United States Navy did not evolve into the most powerful carrier navy in the world solely on its ability to quickly procure thousands of airplanes and hundreds of aircraft carriers. Rather, it was the combination of such materiel and the aircraft technician who kept the carrier fleet combat ready that led to the United States' victory in the Pacific over Japan.

Between 1941-1945, the United States Navy expanded its aircraft carrier operations to levels unimaginable only a few years earlier. During the interwar period,

the navy had grappled with how to best utilize its small fleet of aircraft carriers. A strong carrier navy gave a nation-state the ability to project power anywhere on the planet. The US Navy did its best to make this a reality, but unfortunately throughout the interwar period, Navy leadership focused more on the weapons of naval aviation than on the skilled labor that would become necessary to support a protracted naval war of attrition.

There were a few individuals, however, who recognized the navy's lapses in planning for the future of naval aviation and did something about it. In World War II carrier aviation would become much more than new airplanes, ships, or tactics—the role of the enlisted aviation technician, flight deck crews, and aircrew, combined with aircraft, carriers, tactics, and policy made victory in the Pacific a reality. This dissertation will focus on one of these heretofore ignored groups, the enlisted aviation technicians.

My research addresses a significant but overlooked problem in historical accounts of the development of American carrier aviation.[1] The majority of scholarly and popular writing on this subject has attributed the victory of the U.S. Navy in the Pacific War in 1945 to the superiority of American carrier technology and tactics. These advantages it has claimed were based on the massive production of carriers and aircraft, and the excellence of American naval leaders and pilots. This assertion is valid up to a point, but is not a complete explanation. The waging of carrier warfare against a formidable opponent such as the Japanese Navy involved intense operations over unprecedented distances, in harsh weather, and for a protracted period of time. The viability of the

[1] My intention is to continue research and writing in this subject area post-doc. There is too much material to try and condense all aspects into a single manuscript. Limitations placed upon my time-to-degree required me to maintain a narrower focus in my research than if I had an extra year to complete.

carrier as the primary strike force of the fleet was thus dependent upon the work of large numbers of skilled technical maintenance personnel, who kept its airplanes flying.

In order to meet the labor needs of an aircraft carrier-centric fleet, the U.S. Navy would have to reconsider its personnel and training policies that had been in effect throughout the interwar years. How the aviation navy managed the rapid growth in technical personnel beginning a year before Pearl Harbor is a story that stands on its own, but can be linked to larger issues. Connecting the technical training of the enlisted naval aviation technician with their efforts to maintain naval aircraft in good working order, and the evolution of naval aviation maintenance policies throughout the Pacific War illustrates that logistical factors had an equitable influence on operational outcomes as did the actual fighting.

For most of the interwar period, the effectiveness of naval aviation was limited by the small number of carriers and the low performance of aircraft. Battleships remained the main fighting arm of the Fleet, with carriers relegated to a supporting role. Until the 1930s, the primary role of naval aircraft had been scouting, air defense of the battle group, and spotting for naval gunfire. Carrier aircraft had little in the way of strike (air-to-ground) capability due to the limited horsepower of engines and weapons technology of the time. The navy had explored various carrier attack scenarios in the Naval War College's fleet problems (wargames) in earnest beginning in 1929. However, these were simulated exercises that did not utilize live ordnance, so results were academic at best. Live operations were limited by the number of U.S. aircraft carriers in existence.

Until 1935, the U.S. Navy operated with just three aircraft carriers. Within the navy's Bureau of Aeronautics (BuAer) and the Bureau of Navigation (BuNav), there was

little concern with meeting the skilled labor requirement for aviation activities. This was due in part to the small contingent of aviation technicians necessary to manage the even smaller fleet of airplanes, which numbered in the hundreds for most of the decade. Annual reports from the Chief of BuAer make note of 754 aircraft on hand in 1934 and only 958 in 1936.[2] The United States' arsenal of both land and ship-based aircraft never rose above 1000 until 1937.[3] Thus, the approximately ten thousand sailors assigned to aviation since the beginning of the decade had seemed sufficient in a peacetime navy.

The management of BuAer's enlisted workforce was accomplished within the confines of smaller divisions. Officers, mainly pilots, were given priority and attention in the process of personnel assignments, whereas enlisted personnel were shuffled around internally as needed. One account recalls that there was a "complete lack of individual attention" given to the enlisted aviation technician by BuAer leadership.[4] It was not until 1940 that Rear Admiral John Henry Towers, Chief of BuAer, acknowledged the fact that the impending shortage of aviation technicians would be detrimental to the strength of the Fleet. Even though BuAer had begun to make changes to the distribution and training of aviation ratings in 1940, the lack of foresight kept the labor force of the navy's air arm from reaching substantial strength for another two years.[5]

BuAer implemented its most effective changes in the training system for aviation technicians a year before entering the War. These efforts eventually re-structured naval aircraft maintenance, technical training, and administration. New schools and training

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[2] See U.S. Navy BuAer *Annual Report of the Bureau of Aeronautics* for years 1934-1936.
[3] "Extracts from the Annual Report of the Bureau of Aeronautics as Submitted by Rear Admiral A. B. Cook, U.S. Navy, to the Secretary of the Navy, for Fiscal Year 1937," November 12, 1937.
[4] Office of Deputy Chief of Naval Operations (Air), "Aviation Personnel, 1939-45," in *United States Naval Administration in World War II*, vol. 22 (Washington D.C.: U.S. Government Printing Office, 1959), 323-325,338.
[5] Ibid, 150-152

commands were formed to absorb the massive influx of personnel. Maintenance policies and procedures were adapted to meet the challenges of carrier naval warfare. Efficiency at aircraft overhaul and repair facilities became critical, as did supplying the Fleet with either replacement parts or entirely new airplanes.

This dissertation is a chronicle of how an institution adapts to meet changing needs over time. The structure and size of the enlisted labor force of the aviation navy changed dramatically between 1939 and 1945. During the preceding interwar years, very little concern was given to the importance of the naval aircraft technician. However, the Bureau of Aeronautics made great strides in aviation technology and tactics in the fifteen years since its first aircraft carrier, *Langley* (CV-1), began full scale aircraft operations. Yet, consideration on how best to meet the future labor requirements of aircraft maintenance were routinely ignored or overlooked. The , small contingent of aircraft carrier forces at the time did not necessitate significant changes to the status quo. Production of carriers and aircraft did not reach its zenith until two years into the War. This delay allowed naval aviation to expand the size of its skilled labor force and aircraft technicians, at the same time that industry was ramping up production of ships and airplanes.

I cannot say definitively whether or not shortages in skilled labor from 1940-1943 had significant effects on the U.S. Navy's ability to conduct carrier operations in the Pacific. The concurrent deficiency in the historical literature on naval logistics and materiel has made such an argument impossible to prove or disprove. But, a counter-factual question is worth considering: had the U.S. carrier forces been at full strength in

1942-43, would the navy have been able to sustain combat operations with its quality and quantity of maintenance personnel it possessed?

After 1943, the supply of aircraft technicians was sufficient to support the growing fleet of carrier task forces. As industry produced more airplanes and aircraft carriers, the technical schools of the newly commissioned Naval Aviation Technical Training Command (NATTC) delivered a steady stream of trained enlisted technicians. As the balance of power in the Pacific began to shift toward the United States in late 1943, the numbers of aviation technicians swelled, along with the pilots, airplanes, and ships. It was at this point that the strength of the Fast Carrier Task Forces, which have been given so much credit for their role in the Pacific War, were able to realize their potential and change the course of the war.

A careful analysis of the materiel and manpower buildup over the course of the war in terms of raw numbers, illustrates the enormous challenge that this posed for the administrative leadership of the navy. On 31 December 1940, the navy recorded an inventory of 245 fighter aircraft, 442 dive bombers, and 112 torpedo bombers, a total of only 799 carrier-based airplanes. Until this point, the nearly six thousand aircraft technicians the navy had in its ranks had been sufficient. During the previous year, there was an effort to increase the number of enlisted technicians, along with pilots and new aircraft. Until the *Essex* was launched in late 1942, the combined total aircraft capacity of all eight U.S. carriers in commission was a little over 600. What personnel planners could not know was that by 31 August 1945, the navy would boast 14,748 fighters, 4,771 dive bombers, and 5,181 torpedo bombers available for combat operations—an increase of

thirty-times the total size of carrier-based airplanes available just five years earlier.[6] Additionally, by 1945, the navy reported an inventory of twenty fleet carriers (CV), eight light carriers (CVL), and seventy escort carriers (CVE). The size of this armada offered a capability to operate an air force of over 4000 carrier-based aircraft at one time.[7]

Quantifying this in terms of aviation fuel, the U.S. Navy purchased 566,000 barrels of aviation fuel during the last six months of 1940 to supply a half-year's flight hours. During the second half of 1942, that acquisition jumped to 3,220,000. By 1944, the number reached 16,888,000. In the first six months of 1945, naval flight operations required 27,077,000 barrels of aviation gasoline.[8] With regards to aviation personnel, a year after the attack on Pearl Harbor, the number of enlisted men assigned to aviation activities was ten times that of July 1940. By the end of the war, the navy reported nearly 250,000 enlisted personnel serving in the air arm of the navy.[9]

Managing an expansion of this proportion was no small feat, and one might assume a very attractive subject for naval historians. Yet the opposite is the case. Exactly how the navy dealt with the surge of men and machines after 1940 has been completely overlooked in World War II studies of naval aviation warfare. Twentieth century naval histories have a tendency to be voluminous in accounts of materiel and operations but shallow in administrative studies. In other words, the majority of World War II naval historians have spent their time focused on what the navy did, but not how such efforts and actions were sustained. This dissertation will offer a long overdue and much needed corrective.

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[6] "Annual Report of the Secretary of Navy: Fiscal Year 1945" (Department of the Navy, 1946), A-55.
[7] This figure is derived from an estimate of 100 aircraft per CV, thirty per CVL, and thirty per CVE.
[8] "Annual Report of the Secretary of Navy: Fiscal Year 1945," A-77.
[9] "Annual Report of the Secretary of Navy: Fiscal Year 1945," A-21, A-49.

My research identifies and examines the vocational processes and policies that the navy enacted in attempt to meet the skilled labor demands of carrier aviation. Historians have failed to ask serious questions regarding how the navy obtained a highly-skilled labor force to support wartime-levels of aircraft operations at sea and ashore. Necessary questions—such as how did the carrier's aircraft squadrons maintain a high degree of readiness during long periods of sustained combat operations; what were the stressors on aircraft readiness while embarked on the carrier and how did the navy combat them; what impact did the availability of skilled labor of aviation mechanics have on the war at sea; or how did the navy train and retain enlisted aviation mechanics—have not been asked. Present and past writers have, however, delivered ample studies on navy pilots and their training, tactics, admiralship, and technology. Thus, I remain well clear of any serious discussion of such topics, unless they pertain to the role of the aircraft technician or contribute to an understanding of aircraft maintenance at sea. When discussing wartime operations, I focus mainly on the war in the Pacific, rather than the Atlantic. This is due simply to the fact that the vast majority of U.S. aircraft carrier operations were carried out in the Pacific Ocean in the war against Japan.

The purpose of my dissertation is to study untilled but nevertheless important ground. Ultimately, my research provides insight and a better understanding of how modern navies adapt their training and personnel to meet wartime demands. Increased materiel acquisition, changing defense policies, and surges in manpower requirements do not occur in a vacuum. This work examines the story of that which happened at the mid-to-lower levels of naval aviation operations. One could almost consider it a "bottom-up" view of naval aviation in World War II. Just as the aircraft mechanic works below the

flight deck in the hangar of an aircraft carrier, this dissertation works below the top-level histories of romantic images of fighting admirals, dashing pilots, great battles, and triumphant technological innovation.

Combing the historiography of World War II naval history, one is hard pressed to find any significant studies on the subject of the aircraft technician or naval aviation maintenance. There are a few references to the aircraft technician amongst the oversized annuals of Naval Aviation that hold places on the coffee tables of commanding officers and admirals. Probably the most well-known publication of this sort is M. Hill Goodspeed's *U.S. Naval Aviation* (2001). In it, he states that one of the factors that contributed to the success of U.S. carrier task forces in World War II was the "navy's system of very successful schools…[that] graduated …mechanics, aircraft ordnancemen, and all other specialists…"[10] But no details are given as to how that system operated for the enlisted aircraft mechanic.

Naval historian Clark G. Reynolds argued in his pivotal *Fast Carriers: The Forging of an Air Navy* that it was the "air admirals" such as John Towers, Frederick Sherman, Joseph Clark, and Marc Mitscher who deserve the greatest credit for victory in the Pacific. Admiral Nimitz and General MacArthur are viewed as prominent agents for sure, but their vision was something other than a war predicated on carrier warfare. I do not think Reynold's argument is invalid, but simply incomplete. His thesis that the navy did not make headway battling back the Japanese until the emergence of the *Essex*-class fast carriers in 1943 is unsatisfactory because he fails to recognize what was happening

[10] M. Hill Goodspeed and Rick Burgess, eds., *U.S. Naval Aviation* (Pensacola, FL: Naval Aviation Museum Foundation, 2001), 119.

on or below the flight deck or inside the classrooms of the navy's aviation technical training schools.[11]

Historian Norman Friedman, arguably the most authoritative source on the history of the aircraft carrier, has contributed more data than any other individual to the subject of carrier warfare. However, he has not given us an account from the technical school, flight line, or hangar deck point of view. He makes a brief mention of maintenance personnel training in his collaboration with Thomas C. Hone and Mark D. Mandeles, *American and British Aircraft Carrier Development: 1919-1941,* giving credit to the U.S. for producing "well-schooled pilots, aircrew, and maintenance personnel in short order," but he provides no other specifics.[12] Additionally, there is mention of the rapid advances in aircraft engine horsepower after 1935, but he neglects to address it in terms of the aircraft technician or maintenance schools.[13] There is a perceptible awareness of this critical piece of naval aviation's growth and sustainment from the interwar period into World War II, but little more than a few sentences are dedicated to it. The first Chief of the Bureau of Aeronautics, Admiral William A. Moffett, --characterized as a "bureaucratic entrepreneur" --and the accomplishments of his strategic relationships with senior government officials and naval officers alike takes center-stage in the majority of naval aviation historiography.[14]

William Trimble's *Admiral William A. Moffett: Architect of Naval Aviation* is a biography that should be on every naval historian's book list. However, if a reader is

[11] Clark G. Reynolds, *The Fast Carriers: The Forging of an Air Navy* (Annapolis, MD: Naval Institute Press, 1968).
[12] Norman Friedman, Thomas C. Hone, and Mark D. Mandeles, *American and British Aircraft Carrier Development 1919-1941* (Annapolis, MD: Naval Institute Press, 1999), 173.
[13] Friedman, Hone, and Mandeles, 179.
[14] Friedman, Hone, and Mandeles, 181–85.

seeking a history of the aircraft technician, he or she will not find it here. The more prominent problems facing BuAer during Moffett's tenure, such as technological research and development, future career paths for naval aviators, and the turf war with the battleship navy take precedence within his book.[15] Trimble's thorough work on the Naval Aircraft Factory, *Wings for the Navy,* comes closer to giving aviation maintenance its due, but focuses too much on the Philadelphia facility and it's evolution as an overhaul and aircraft production facility to deliver a cogent history of naval aircraft maintenance during the interwar years or after.[16] Samuel Eliot Morison's multi-volume *History of World War II Naval Operations* references the role of naval aviation during the interwar period in his introduction--written by Dudley Knox--stating, "The most important constructive development between the two World Wars was that of integrating naval aviation with the Fleet." However, there was no further discussion of how that was accomplished with regards to the technical work force.[17] Timothy Jackson and Stanley Carpenter script a detailed account of the impact that the Two Ocean Act of 1940 had on the status of carrier aviation in *One Hundred Years of U.S. Navy Air Power*, yet their analysis is surprisingly devoid of any mention of the Bureau of Aeronautics' or Bureau of Navigation's efforts to amend the aviation technical training program in order to meet the demands of a 15,000 plane navy.[18]

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[15] William Trimble, *Admiral William A. Moffett: Architect of Naval Aviation* (Washington D.C.: Smithsonian Institution Press, 1994).
[16] William F. Trimble, *Wings for the Navy: A History of the Naval Aircraft Factory 1917-1956* (Annapolis, MD: Naval Institute Press, 1990).
[17] Samuel Eliot Morison, *History of United States Naval Operations in World War II*, vol. I (Boston: Little, Brown and Company, 1960), xlix.
[18] Douglas V. Smith, ed., *One Hundred Years of Airpower* (Annapolis, MD: Naval Institute Press, 2010), chap. 8.

I have found that the most informative material on the interwar and wartime naval aviation maintenance is found in the Naval History and Heritage Command's collection of 175 unpublished administrative naval histories of World War II. These manuscripts, which encompass nearly 300 bound volumes, were prepared by historical units of the U.S. Navy beginning in 1943 and considered complete in 1959. In particular, those of the Deputy Chief of Naval Operations for Air (DCNO for Air) and the Bureau of Aeronautics contain the most relevant information to the topic of aviation maintenance and personnel. Smaller, even more discreet individual unit histories and reports that were submitted to the Naval History Office or other upper echelon commands within the Department of the Navy throughout the War and following are full of valuable information relating to aviation maintenance. In combination, the data within these volumes presents the best picture of what the navy was facing in terms of shortages in manpower and lack of training at the outset of the war. They also deliver a fascinating account of the responsive changes the U.S. Navy made over the first three years of the war. A.R. Buchanan's *The Navy's Air War*, a book-length manuscript published in conjunction with the official histories, spends a considerable amount of time on the importance of aircraft maintenance and the technician. Unfortunately, it falls short by not delivering a complete picture of the navy's shortcomings in the leadup and entry into the Pacific War.[19]

To date, there is no authoritative source that addresses the overarching question of how the navy managed the buildup and training of its skilled labor force of aircraft technicians nor how this affected fleet operations. However, compiling the accounts and

[19] A. R. Buchanan, ed., *The Navy's Air War* (New York: Harper, 1947).

data from the aforementioned documents--as well as other primary source materials such as navy manuals, post-war operational studies, operational reports, Congressional hearings, and the personal accounts of life as an aircraft technician--has provided me with a clearer understanding behind the policy decisions before, during, and after the War.[20] This dissertation is the first scholarly account to address this subject in earnest, and to do so with the archival evidence to support its answers.

Historians Jon Sumida and David Rosenberg argued that twentieth century navies have been shaped by "matters related to machines, men, manufacturing, management, and money."[21] Comprehensive histories of U.S. naval administration--other than the aforementioned--are scarce. Operational, or "battle history" as characterized by military historian John Keegan, is plentiful.[22] But as Sumida and Rosenberg have challenged, a truly comprehensive history is unattainable without addressing the relationship between the administrative and the operational. My intention is not to weave a counter-argument into the canon of World War II naval history, but to add yet another layer to the already-complex saga.

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This dissertation is generally organized chronologically, yet occasionally the subject material requires a brief topical study instead. Chapter 1 serves as an introduction to the state of naval aviation after the commissioning of the navy's first aircraft carrier,

[20]Some of the most valuable data to this dissertation in regards to quantifying the impact of aircraft maintenance on the carrier during wartime operations is found in the unpublished study "Operational Experience of Fast Carrier Task Forces in World War II" (Office of the Secretary of Defense, Weapons Systems Evaluation Group, August 15, 1951), Carriers Collection, Box 27, NHHC.
[21] Jon T. Sumida and David A. Rosenberg, "Machines, Men, Manufacturing, Management, and Money: The Study of Navies as Complex Organizations and the Transformation of Twentieth Century Naval History," in *Doing Naval History: Essays Toward Improvement*, ed. John B. Hattendorf (Newport R.I.: Naval War College Press, 1995), 25.
[22] John Keegan, *The Face of Battle* (London: Penguin Books, 1978).

the *Langley.*[23] U.S. Naval Aviation in the interwar period only generated a moderate level of interest compared to other naval weapon systems due to the small number of carriers and the limited performance of aircraft. Battleships remained the main fighting arm of the Fleet, with carriers relegated to a supporting role. The limitations of the Washington Naval Treaty of 1922 restricted overall tonnage of capital ships and limited new construction. The next two U.S. carriers, *Lexington* and *Saratoga* were reconfigured battle cruisers already under construction when the treaty was signed. Until 1935, the navy operated with just three aircraft carriers.[24]

By the outbreak of war in December 1941, the U.S. Navy had managed to commission four more large aircraft carriers (CV), plus one escort carrier (CVE). The smaller design of the new carriers and the lapse of the Washington Naval Accords in 1937 allowed for the additional vessels. Due to this increase, the navy's carrier aircraft operating strength would more than double to approximately 600. This was an impressive surge in capability, but not one that caused great concern with regards to maintenance manpower.

Chapter 2 takes a closer look at the status of Fleet aircraft maintenance and technical training at the end of the interwar period. The labor force required for the small contingent of naval aircraft at shore and at sea had been sufficient since the days of Rear Admiral William Moffett and the creation of the Bureau of Aeronautics. However, with

[23] USS *Langley* (CV-1) was converted into a seaplane tender in 1937 and saw combat against the Japanese during the first months of the war. On February 27, 1942, it was attacked by Japanese aircraft and suffered irreparable damage. *Langley* was scuttled by U.S. forces shortly thereafter rather than risking the ship falling into enemy hands.

[24] The Washington Naval Treaty of 1922 put a limit on combined aircraft carrier tonnage at 135,000 and 27,000 each (although the limits were often exceeded during construction as seen in *Lexington* and *Saratoga* at 36,000 tons each) The *Ranger* was designed in 1925 as a smaller version of the *Lexington*-class (14,000 tons), similar in size to the *Langley*. The three *Yorktown* carriers (*Yorktown, Enterprise,* and *Hornet*) each weighed approximately 20,000 tons in order to adhere to the weight limits of the applicable treaties. The *Wasp* was in its own class, smaller than the *Yorktown*, at approximately 15,000 tons. The *Essex*-class carriers (27,000 tons) were designed after the limits of the treaty were abandoned after 1937.

the threat of a second world war and naval aviation looking to be a major player in that conflict, personnel and training requirements were thrust to the forefront of war preparations.

Rear Admiral Towers, Chief of the Bureau of Aeronautics from 1939-1942, recognized the need for more pilots and aviation officers, but he missed signals that training enlisted technicians for the navy's aviation labor force was equally important. In his defense, most of the navy's leadership also overlooked the enlisted component of preparing to fight an air war at sea as pilot training and aircraft acquisition received most of their attention. It was not until the President authorized a massive increase in the naval aircraft inventory in 1940 that Towers began considering changes in personnel administration to meet the oncoming challenges.

In the latter part of 1941, BuAer's repetitive calls for assistance resulted in the navy modifying its recruitment policies and implementing more Reserve activations for aviation personnel. Yet, even as these revisions filled in the gaps surrounding overall numbers of enlisted aviation technicians, quantity only solved half of the problem. The Fleet needed highly-skilled technicians that could maintain new airplanes and who also were capable of contending with constantly changing aircraft technology. Quantity by itself was not enough to do the job. The quality of its aviation labor force was equally important as the United States entered World War II.

Chapter 3 acknowledges that in 1940, BuAer recognized the need to change its training system for aviation technical ratings. The expansion that naval aviation was undergoing created the need for a more robust and technically advanced training program for the aviation labor force. Administrative changes in how BuAer managed the

technical training program afforded the navy the opportunity to open multiple technical Trade Schools. These Trade Schools were responsible for quickly producing high numbers of trained technicians ready for the Fleet.

The need to establish standards for prospective students, as well as the curricula, forced BuAer to reform its processes. It consolidated a national network of technical trade schools into four primary locations. BuAer also contracted with industry partners who offered specialized schooling for naval technicians at their factories as a supplement to the navy trade schools. Students were admitted into the trade and factory schools based on standardized testing scores. Over a period of just four years, BuAer transformed a non-standardized process of on-the-job technical training into a massive network of standardized schools structured to educate a technical workforce numbering one-quarter of a million men and women.

The focus of chapter 4 is the establishment of the Naval Aviation Technical Training Command (NATTC). NATTC was responsible for creating the most technologically advanced labor force the world had ever seen. The first year of World War II proved to be a much bigger burden on BuAer and the Bureau of Naval Personnel (BuPers) than was expected.[25] The continued personnel challenges since Naval Aviation's period of expansion was authorized in 1940 were being met on paper, but the raw numbers were misleading. The number of trained aircraft technicians graduating from naval trade schools was slowly erasing the deficit of enlisted aviation ratings in the Fleet. Unfortunately, the quality of their training left much to be desired.

[25] The Bureau of Navigation (BuNav) was renamed the Bureau of Naval Personnel (BuPers) in 1942. The acronyms will used interchangeably throughout this dissertation.

Problems with standardization, curricula, budgeting, physical maintenance of the schools, and instructor training forced BuAer and BuPers to collaborate on a new administrative structure that would take primary responsibility for the education of the technical aviation ratings. NATTC was established on 11 September 1942. The command was assigned responsibility for all aspects of technical aviation training. BuPers and BuAer worked alongside NATTC to ensure that quotas, budgets, and material needs were met as World War II intensified. NATTC changed the face of naval aviation technical training from a disjointed, non-standardized, antiquated program into a modern, progressive-thinking administrative organization.

Chapter 5 explores the transition of aviation maintenance into a specialized labor force aboard the aircraft carrier. Prior to World War II, aircraft maintenance was relatively simple when confined to naval facilities that were located on land and usually in the vicinity of a major naval air station. Maintenance was routinely limited to land-based-work spaces completed by a few skilled technicians that were considered experts on all parts of airplanes. It was even common practice for pilots to work on their own airplanes along with a small crew of enlisted technicians. In effect, aircraft maintenance in the peacetime navy was a highly personalized operation that attracted little attention from anyone outside of the pilots and technicians, themselves.

The final chapter examines and analyzes the available data-sets of aircraft availability during the war and suggests a connection with the availability of technicians and supplies. Procurement policies with respect to spare parts and life expectancies of carrier-based aircraft had a profound impact on the navy's progress in the latter half of the war. An analysis of yearly budgets and the fluctuating cost of aircraft and spare parts

also reflected the changing nature of aviation maintenance policy in the latter half of the war.

In 1943, a mid-year survey was given to carrier aviation officers. In it, supply and spare parts were identified as the greatest detriments to the Fleet. Supply and logistics played a critical role in the WWII carrier warfare. The effectiveness of the Fast Carrier Task Force depended on the availability of its aircraft. The number of "mission capable" aircraft directly reflected the supply system, as well as the technicians' ability to do their jobs effectively. Ultimately, revisions in naval aircraft maintenance policy and procedures met the challenges of supply and repair. As the aircraft industry's rates of production soared, the navy no longer had to rely solely on the technician to "keep em' flying."[26] The vast number of airplanes being delivered on a monthly basis by 1944 changed the nature of aircraft maintenance at sea and probably shortened the war.

By 1944, the striking power of the United States Navy Carrier Task Forces in the Pacific Ocean was unequaled by any other nation. At no other time in modern naval warfare had the world ever experienced such materiel strength and firepower. But machines, manufacturing, and money alone do not win wars. Even in the midst of vast technological improvement and weapons' capability, people still mattered. This is a study in the administration, training, and management of a skilled labor force that was vital in the defeat of the Imperial Japanese Navy in World War II-the United States Navy's enlisted aircraft technician and its aviation maintenance program.

[26] Often found on recruiting posters or in maintenance handbooks, "Keep 'em flying" was the slogan for the Navy's aircraft maintenance force throughout the war.

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Chapter 1: Progress and Shortcomings

In the 1920s, the battleship was considered the preeminent weapon of naval warfare. U.S. Navy carrier aviation was a novel concept that many considered to be nothing more than a future auxiliary force in support of the battleship fleet. Twenty years later, these roles would be reversed, with the main burden of fighting assumed by carriers. This change in status came as a result of advances in aircraft performance, improvements in carrier design, increases in carrier numbers, and the development of new operational practices in response to war experience. However, the spectacular success of the American carrier forces in the war against Japan was not just a matter of combat with planes, pilots, and platforms, but it also required an enormous body of skilled technicians to service and maintain the state-of-the-art airframes, complex engines, electrical, hydraulic, and ordnance systems under the harsh conditions of war at sea. The practicability of the carrier formations that were the cutting edge of the U.S. Navy's strike capability rested upon the labor of enlisted aircraft technicians. While those in charge of Bureau of Aeronautics (BuAer) had recognized the importance of aircraft mechanics during the interwar period, they failed to anticipate the level of effort that the colossal expansion of naval aviation beginning in 1940 would necessitate. A growth in skilled service personnel like never before would be required. The following three years would thus prove to be an uncomfortable, and even difficult period of playing catch-up with regards to aviation technical training and labor supply for the navy.

A discussion of U.S. naval aviation in the 1920s and 1930s must consider the influence of the British Royal Navy (RN) in the First World War. During World War I,

the RN possessed the most advanced naval air arm in the world. U.S. Navy forces operated closely with the British and were influenced by their aircraft carrier operations.[27] The Royal Navy had invented the aircraft carrier and operated aircraft from ships extensively throughout the First World War. British carrier aircraft were utilized mostly in a scouting or reconnaissance role rather than air strikes with bombs or torpedoes. In 1916, plans were drafted for the British aircraft carrier *Hermes*, which was the first purpose-built aircraft carrier.[28] The British converted an ocean liner, battleship, and three battle cruisers into carriers during the 1920s.

After 1930, the Royal Navy added no new aircraft carriers until commissioning the *Ark Royal* in 1938. None of the six operable British carriers at that time carried more than forty-eight aircraft.[29] The U.S. would not challenge the Royal Navy's number of aircraft carriers at sea until the end of the interwar period. However, what the U.S. Navy carrier fleet substituted capability for its lack of quantity. The larger American carriers built after the Washington Naval Conference maximized the number of airplanes on board, never dropping below seventy-two. This held true until the navy began building smaller escort and light carriers on the eve of the WW II, which typically deployed with an average of thirty airplanes.

After World War I, the U.S. Navy's interest in carrier aviation briefly waned as sea planes (aka "flying boats") and land-based scouting operations took precedence over the development of carrier tactics and procedures. A year after war ended, the navy decided to convert the *Jupiter*, a coal collier, into its first aircraft carrier, the USS *Langley*

[27] Norman Friedman, *Fighters Over the Fleet* (Annapolis, MD: Naval Institute Press, 2016), 28.
[28] Friedman, 13–15.
[29] Bureau of Naval Personnel, *Navy Wings* (Washington D.C.: U.S. Government Printing Office, 1955), 30.

(CV-1). *Langley* began its conversion in 1920 and was commissioned as a fighting warship in 1922. Initially, *Langley* did not embark any aircraft squadrons for extended periods but was only used for training pilots, testing carrier equipment such as catapults and arresting gear, and developing tactics through fleet battle experiments.[30] While *Langley* provided a test bed for the new technology, plans for two more aircraft carriers were in development.

Langley did not embark her first permanent squadron, Fighting Squadron Two (VF-2) and its twelve VE-7S bi-wing fighters until 1924. With its relatively small hangar space, it was initially designed to only operate a dozen aircraft at one time. *Langley* was smaller and slower than all other subsequent U.S. aircraft carriers.[31] Her flight deck was only 534 feet in length, nearly 350 feet shorter than that of the final design of *Lexington* (CV-2) and *Saratoga* (CV-3), then under construction. Yet, even with all of its shortcomings, *Langley* served its purpose at a time when the U.S. Navy's experience in aircraft carrier operations was minimal at best.

In 1925, Captain Joseph M. "Bull" Reeves, Commander, Aircraft Squadron, Battle Fleet, designated *Langley* as his flagship. Development of carrier tactics continued in the Fleet with *Langley's* aircraft and pilots. Reeves, an officer who always sought to improve upon the status quo, sought suggestions from his pilots on how to conduct air operations more efficiently.[32] After discussion with aircrew, Reeves initiated keeping all

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[30] Howard Mingos, ed., *The Aircraft Year Book for 1937* (New York, N.Y: Aeronautical Chamber of Commerce of America, Inc., 1937), 88.

[31] USS *Langley* (CV-1) was converted into a seaplane tender in 1937 and saw combat against the Japanese during the first months of the war, On February 27, 1942, she was attacked by Japanese aircraft and suffered irreparable damage. *Langley* was scuttled by U.S. forces shortly thereafter rather than risking the ship falling into enemy hands.

[32] Reeves, an 1894 graduate of the U.S. Naval Academy, is credited with wearing the first football helmet in an 1893 Naval Academy football game. The helmet was made for him by an Annapolis shoemaker who crafted the helmet after Reeves was told by a doctor that if he took one more hit to the head in a game, he

aircraft on the flight deck rather than in the hanger for the duration of at-sea maneuvers. Until this point, aircraft had been moved up and down *via* elevator after every launch/landing cycle, making for a tedious and lengthy operation that was burdensome on the flight deck crews responsible for conducting aircraft movement. Reeves' new method required maneuvering each plane to the bow of the ship, forward of the landing zone and protected by a crash barrier after landing. Once all aircraft were aboard, they were repositioned to the stern of the ship in preparation for the next launch cycle. Reeves' procedure reduced the landing interval between planes to just a few seconds. For the rest of the interwar years, and much of the World War II, U.S. carriers would continue to park airplanes on the flight deck for the majority of underway periods. Routine maintenance and servicing were conducted on the flight deck, and the hangar was used for spare aircraft, parts, and repair only when absolutely necessary. Ultimately, Reeves' ingenuity, albeit admittedly more dangerous than the previous procedure of stowing planes in the hangar after landing, would allow many more aircraft to embark in U.S. carriers.[33]

After promotion to Rear Admiral, Reeves' continued to push the limits of aircraft compliment. In 1928, he decided to have *Langley's* flight deck enlarged in order to operate more aircraft. Upon doing so, he eventually found room for another thirty airplanes, raising *Langley's* new aircraft complement to forty-two. The ship's Commanding Officer, Commander John Henry Towers, future Chief of the Bureau of Aeronautics, did not support the drastic increase in airplanes on his deck. He argued that

risked death or brain damage. Source: Louis Blakely, "History of the Football Helmet," Past Time Sports, accessed April 17, 2019, http://www.pasttimesports.biz/history.html.

[33] Friedman, *Fighters Over the Fleet*, 32.

it was unsafe to clutter the deck with so many airplanes. But Reeves was the Battle Fleet Commander, and had ultimate authority over the Navy's carriers in the Pacific. Reeves was changing the nature of carrier aviation, and did not care whether Towers or anyone else liked it.[34] The decision to keep aircraft parked on the flight deck for long periods may have been a good decision tactically, but as far as aircraft maintenance, it was troublesome. Deck parking exposed the aircraft to one of the most austere environments on the earth—the open ocean.

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Corrosion, a common problem for any aircraft operating in a salt water environment, has plagued naval aviation since Eugene Ely's first shipboard landing in 1911. Acidic salt-laden ocean air and salt water chemically react with metal aircraft parts and accelerate corrosion many times faster than non-ocean air or fresh water. Parking airplanes on the flight deck only made the situation worse due to constant exposure to ocean air and salt spray.

Corrosion of carrier-based aircraft was a relatively minor problem early on, however, due to aircraft design. The Navy's first fighter aircraft, the Vought VE-7 *Bluebird*, was constructed mostly of non-corrosive materials such as wood and fabric. Much of the forward fuselage, however, was covered in sheet metal to withstand the heat generated by the small 180 horsepower (hp) engine. The engine and flight instruments were constructed with metal alloys as well.[35]

[34] Clark G. Reynolds, *Admiral John H. Towers: The Struggle for Naval Air Supremacy* (Annapolis, MD: Naval Institute Press, 1991), 212–15.
[35] William Larkins, *U.S. Navy Aircraft 1921-1941* (Concord, CA: Aviation History Publications, 1961), 23,44,341.

The Bureau of Aeronautics recognized the costly effects of corrosion to its airplanes, as did the U.S. Naval Aircraft Factory (NAF). The NAF had performed all of the overhauls and major maintenance on navy aircraft since 1917, even manufacturing some of its own aircraft directly in its Philadelphia plant. Most of the NAF-built aircraft were of the patrol type such as the PN-9, the navy's first all metal hull "flying boat." Engineers in the NAF spent years experimenting with various metal alloys in hopes of finding one that would resist corrosion and lighten the gross weight of airplanes. Navy aircraft could suffer critical damage from salt corrosion very quickly. Hidden corrosion under the non-metallic "skin" of the airplane was of great concern to aircraft mechanics. It jeopardized the structural integrity of the airframe and weakened aircraft structural parts. Additionally, corroded metal engine parts could fail prematurely, and endanger the lives of the aircrew as well.

The environmental hazards of naval aviation forced scientists, technicians, and aircraft manufacturers to seek alternative materials and coatings that would be both durable and corrosion-resistant. Duralumin, one of the earliest aluminum alloys first used in naval aircraft, showed promise in its durability, but did not hold up well against corrosion. In 1927, a new aluminum alloy called Alclad was introduced to the navy by the aluminum manufacturer Alcoa. Alclad provided the corrosion resistance that the navy desired. It soon became the standard in metal naval aircraft airframes.[36]

As more navy aircraft were flying to and from carriers in the late 1920s, BuAer stepped up its efforts to prevent corrosion. According to the BuAer Manual of 1927, all metallic parts of airplanes were to be treated with a protective coating of rust inhibiting

[36] Trimble, *Wings for the Navy: A History of the Naval Aircraft Factory 1917-1956*, 89–91.

agent and then painted as an extra measure. This procedure would carry over into the supply divisions that packaged aircraft spare parts. It became a standard procedure to apply a coating of rust inhibitor to any spare parts containing metal before packaging or shipment. The navy would continue to battle corrosion throughout the interwar period and beyond. The scientific advances that were made in the prevention of corrosion during this period would have lasting effects on the institution of naval aviation maintenance. Thanks to the aircraft maintenance personnel and procedures of 1920s, naval aviation has continually considered the effects of corrosion on the performance and durability of its aircraft.

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The latter half of the 1920s saw increased aircraft procurement for the Navy in concert with ongoing construction of *Lexington* and *Saratoga.* In 1926 Congress authorized a gradual procurement program for 1,000 additional new airplanes for the navy over a period of five years. In order to best determine the nature of how and what to spend the navy's money and efforts on with regards to aviation over the following five years, a board was convened of progressive-minded supporters of naval aviation. Chaired by Admiral Montgomery Meigs Taylor, the board included some of naval aviation's biggest proponents including William Moffett, "Bull" Reeves, H. E. Yarnell, Theodore G. Ellyson, and Marc Mitscher. All were advocates of a strong aviation navy.[37] The Taylor Board recommended that building a greater number of smaller aircraft

[37] Reeves, Yarnell, and Mitscher would continue to serve naval aviation interests both operationally and administratively throughout World War II.

carriers at a rate of one per annum would be preferable to adding fewer carriers but of larger size like the 36,000-ton *Lexington*. This would permit the navy to increase its carrier fleet, employ the additional aircraft, and still remain within the limits of the 1922 Washington Naval Treaty.[38] Plans for the Navy's fourth carrier, the *Ranger*, were already being drafted, but construction did not commence until after 1930. The proposed carrier build-up was not approved by Congress, most likely due to declining peacetime military budgets and lingering demobilization efforts.[39] BuAer would have to make do with the three carriers it had until the middle of the 1930s.

The other problem with the Five-Year Program was that the plan for a 1,000-plane air force made no provision for additional personnel or personnel support. In 1924, Rear Admiral William A. Moffett, the first Chief of the Bureau of Aeronautics, and his staff, had testified before Congress that for every aircraft operating from U.S. aircraft carriers, an average of eight to ten enlisted aviation technicians were necessary for proper maintenance.[40] At that time, this meant another two to three thousand sailors being assigned to the naval aviation community.[41] Even in naval aviation's earliest years, BuAer acknowledged the importance of the enlisted technician to the success of the air navy, but manpower requirements were not always met. The operation of the navy's

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[38] The Washington Naval Treaty of 1922 put a limit on combined aircraft carrier tonnage at 135,000 and 27,000 each (although the limits were often exceeded during construction as seen in *Lexington* and *Saratoga* at 36,000 tons each) The *Ranger* was designed in 1925 as a smaller version of the *Lexington* class (14,000 tons), similar in size to the *Langley*. The three *Yorktown* carriers (*Yorktown, Enterprise, Hornet*) each weighed approximately 20,000 tons in order to adhere to the weight limits of the applicable treaties. The *Wasp* was in its own class, smaller than the Yorktown, but of similar design, weighing approximately 15,000 tons. The *Essex*-class carriers (27,000 tons) were designed after the limits of the treaty were abandoned after 1937.

[39] Archibald D. Turnbull and Clifford L. Lord, *History of United States Naval Aviation*, 1972 Reprint by Arno Press Inc. (New Haven, CT: Yale University Press, 1949), 260–61.

[40] Office of Deputy Chief of Naval Operations (Air), "Aviation Personnel, 1939-45," 211.

[41] The three carriers in discussion were based on the design of USS *Lexington* (CV-2). The number 3000 was most likely associated with an aircraft complement of 78 airplanes per carrier.

technical service schools suffered in the latter half of the 1920s and formal technical training of new recruits was limited due to lack of funding. Many of BuAer's Assembly and Repair (A&R) Facilities, such as the Naval Aircraft Factory served as informal training venues. Existing technical schools, if not completely shut down, were "skeletonized," leaving a lack of experienced instructors, and therefore trained technicians, throughout the Fleet.[42]

Moffett had estimated that in order to properly operate and maintain 1,000 airplanes, 3,136 rated aviation technicians plus 9,503 general service rated sailors for a total of 12,639 men would be required by 1930.[43] Even with the limited funding for personnel programs, Admiral Moffett, a persuasive and appreciated arbiter between the government and the navy, acquired what BuAer needed in order to survive its aviation labor demands during the leaner years. Remarkably, Moffett nearly reached his goal of twelve thousand men in 1928, even when the navy as a whole, had reduced its overall strength by two thousand during the same period.[44] Unfortunately, progress would stall following Moffett's untimely death in 1933 in the crash of the airship USS *Akron* off the New Jersey coast.

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Labor demands on board the carrier in the early interwar period varied with size of the ship and complement of aircraft. While the *Langley* was originally designed with

[42] Turnbull and Lord, *History of United States Naval Aviation*, 264.
[43] Bureau of Aeronautics, "BUAER Annual Report 1930" (United States Navy, 1930). "Rated" refers to technicians who are skilled in maintenance of aircraft systems, as any trained mechanic would be. "General service" included support personnel for such duties as administration, flight deck operations, or supply. Essentially, those who were not considered airplane mechanics or ordnance technicians.
[44] Turnbull and Lord, *History of United States Naval Aviation*, 265.

twelve embarked aircraft in mind, it was routinely deploying with more than forty by the end of the decade. The *Lexington* and *Saratoga* were each commissioned with the capability to operate seventy-two airplanes but compliments could vary from fifty to eighty.[45] *Langley* required a just under 500 personnel (officers and enlisted) to operate.[46] The *Lexington* was built to deploy with over seventy aircraft and berth 2800 men, including aviation personnel. As the U.S. continued construction of aircraft carriers in the 1930s, the labor requirements of naval aviation grew significantly. The *Ranger* (CV-4) was commissioned in 1934 with an expected compliment of seventy-six aircraft and 2200 men. Eventually, every carrier that would be built under the "CV" designation throughout the Pacific War would sail with no less than 2000 personnel, including between six and seven hundred enlisted aviation personnel. The escort carriers (CVE) and light carriers (CVL), the bulk of which would be built after World War II began, required a much smaller labor footprint as their aircraft compliment remained near thirty. Their labor requirement was only a few hundred greater than that of the *Langley*.[47]

As in the *Langley* design, carrier hangars were originally intended as a storage location for spare airplanes, providing an on-board replacement to the strike force when necessary. In stowing the replacements below, the flight deck was less cluttered with parked aircraft when conducting flight operations. The protected environment of the hangar was also beneficial to preserving the material condition of the airframes. But the inefficiency of the aircraft elevators onboard made getting quick replacements to the flight deck a problem. Aircrew and maintenance personnel preferred to use the hangar

[45] Larkins, *U.S. Navy Aircraft 1921-1941*, 90, 146.
[46] Norman Friedman, *U.S. Aircraft Carriers* (Annapolis, MD: United States Naval Institute, 1983), 389.
[47] Friedman, 391–94.

deck only for critical aircraft maintenance and repair that could not be performed on deck, as well as storage of spare aircraft and spare parts.[48] Storing the majority of its aircraft on deck increased the pace at which aircraft carriers could affect launch and recovery cycles, but the procedure, as previously discussed, could be costly to the airframes. More airframes on deck would require more technicians to service and properly maintain them.

By June 1934, both *Lexington* and *Saratoga* were operating with eighty airplanes on board. The squadrons assigned were a mix of fighters, scouts, and torpedo bombers. When embarked on the carrier, the squadrons made up what was termed the "Carrier Air Group" (CAG). During the interwar years, squadrons were designed as completely autonomous units. Even though squadrons were often assigned to a single ship for many years, flight operations at sea were considered temporary, and thus all maintenance personnel were assigned to the squadron vice the ship. An average enlisted complement of a squadron before the war was 120 men, which included technicians and non-aviation ratings such yeomen, cooks, bakers, and pharmacist's mates.[49] Officer numbers varied anywhere from twenty to fifty depending on the number of airplanes per squadron and whether they were single-seat or two-seat designs.

The size of squadrons and air groups increased over the interwar and war years. Much of this expansion should be attributed to the ingenuity of the navy's engineering leadership. During the early 1930s, the Bureau of Construction and Repair (BUCON) and BuAer began experimenting with a procedure called "tricing" in order to free up limited deck space in the hangar. This procedure permitted completely assembled spare

[48] Robert C. Stern, *The Lexington Class Carriers* (Annapolis, MD: Naval Institute Press, 1993), 109.
[49] Stern, 149.

or damaged aircraft to be "hung" in the overhead with a system of pulleys and wires. In the *Lexington*-class carriers, it allowed an additional seventeen aircraft to be stowed aboard. The tall height of the hangar spaces provided enough clearance underneath to park another airplane, allowing aviation technicians to conduct maintenance as necessary.[50] It was not an easy procedure, but to the ship's Air Department, it was well worth the trouble. One officer recollected, "It [tricing gear] made a difference. We could put 17 more airplanes on the ship. If you could trice up 17 of them, it was well worth taking a lot of inconvenience for."[51] Ultimately, more planes on board meant more technicians needed to be available to maintain them, but institutional change from the "way it had always been done" was difficult for the navy's bureaucracy to embrace. Therefore, the navy would soon find itself shorthanded on the skilled labor necessary to properly support the growing fleet of carriers.

The final five years before the War afforded the U.S. an opportunity to add another five carriers to its order of battle. The 14,500-ton *Ranger* had not exhausted the Washington Naval Treaty's total allowance for U.S. carrier tonnage, and thus construction began on the *Yorktown* (CV-5) and *Enterprise* (CV-6) in 1934. Each were designed to carry at least ninety aircraft. Commissioned in 1937, their tonnage was less than that of the '*Lexingtons,*' only weighing approximately 20,000 tons. The personnel compliment was 2200 total, with approximately 700 assigned to aviation duties. Construction of a third vessel, the *Wasp* (CV-7), began in 1936 and was completed in 1940. It was a smaller version of the *Yorktown*-class, designed to only carry seventy-six aircraft. Its enlisted

[50] Stern, 109–10; Norman Friedman, *Carrier Air Power* (New York, N.Y: Rutledge Press, 1981), 112.
[51] Interview of Commander Alfred M. Pride, BUSHIPS Correspondence, June 16, 1942. As quoted in Stern, *The Lexington Class Carriers*, 110.

aviation personnel complement was about fifty less than that of the larger *Yorktown*.[52] The lapse of the Washington accords in 1937 allowed work to begin on *Hornet* (CV-8), a third unit of the *Yorktown*-class, which was commissioned in December 1940. By the outbreak of war in December 1941, these four warships, plus one smaller escort carrier, the *Long Island* (CVE-1), had added a capability of deploying another 360 aircraft to the almost 250 already operating from the *Lexington*, *Saratoga*, and *Ranger*, for a grand total of just over 600.[53]

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The 600 aircraft that were operating from U.S. carriers in 1941 and beyond were technological marvels compared to the VE-7S bi-wing fighters that were landing on the deck of the *Langley* in 1924. The most significant advances were in their performance capabilities such as engine design, horsepower, and airspeed.[54] Due to the extreme operating environments of most naval aircraft, BuAer favored air-cooled radial engines over liquid cooled. Compared to liquid-cooled engines, they weighed considerably less, had better reliability, and were less vulnerable to gunfire.[55] Air-cooled engines were also less prone to radiator and coolant line breakage that could result from sea-plane water landings in heavy seas and high impact carrier landings.

Progress was not only made in engine power and performance in other areas as well. Increased reliability and reduction of maintenance costs in aircraft engines took

[52] Friedman, *U.S. Aircraft Carriers*, 392–93.
[53] Ibid.; *Langley* was decommissioned as an aircraft carrier in 1936 and converted into a seaplane tender in 1937.
[54] Airspeed figures are given in knots (kts), not miles per hour (mph)
[55] Charles McCarthy, "Naval Aircraft Design in the Mid-1930's," *Technology and Culture* 4, no. 2 (Spring 1963): 173.

priority in much of BuAer's research and development. The navy's Bureau of Supplies and Accounts assisted with implementing a new cost accounting system at the overhaul shops, also known as Assembly and Repair (A&R) facilities. This new accounting system reduced the number of man hours required for airplane and engine overhaul. Chief of BuAer at the time, Rear Admiral Ernest J. King boasted that it allowed his Bureau to release 100 enlisted technicians from the overhaul units to serve the Fleet on ships instead. Modifications to *Lexington* and *Saratoga* were also made to accommodate bomb and air-launched torpedo stowage and handling. Corrosion resistant steels and alloys, new enamels, and primers were constantly under development. Improving engine preservative compounds was also noted in the list of BuAer's accomplishments during the interwar period.[56]

The gross weight, wing span, and overall length of navy aircraft also increased. As aircraft design evolved with each new model, the navy had to consider how to operate its new aircraft from carriers that were designed years earlier. This included how and where to park, land, and launch the airplanes. In addition, BuAer and its aircraft technicians had to learn the maintenance procedures for each new engine and aircraft systems.

Carrier fighter aircraft such as the Vought F3B-1 (1928) had an engine rating of 450 horsepower. Its maximum speed was 136 knots and it weighed 2950 pounds. The wing span was 33 feet and overall length was slightly less than 25 feet. The Boeing F4B-4 (1930) increased horsepower to 550 and its airspeed to 147 knots. Gross weight

[56] "Extracts from the Annual Report of the Bureau of Aeronautics as Submitted by Rear Admiral Ernest J. King, U.S. Navy, to the Secretary of the Navy, for Fiscal Year 1934," December 9, 1934.

increased by 200 pounds. But in a sign of times to come, it also added bomb racks under the wings so it could carry a 116-pound bomb under each.

As newer aircraft entered the Fleet, engine ratings increased with every new model. Grumman's FF-2, a modified version of the original FF-1, was delivered to the Fleet in 1933. Its engine was rated at 700 horsepower and overall weight increased to 4826 pounds. Airspeed of the FF-2 increased to 179 knots. Grumman then delivered the F3F in 1935. Its engine horsepower was 950 and maximum speed was 207 knots.[57] The navy's first monoplane fighter, the Brewster F2A *Buffalo*, entered service at the very end of the interwar period. It was delivered in 1939 with 1200 horsepower and a maximum speed of 258 knots. Its gross weight was a very heavy 6538 lbs., but the wing span and overall length were only a couple of feet longer than the earlier F3B-1.

At the risk of operating outside of the chronological boundaries of this chapter, it is necessary to look past the interwar period briefly in order to fully comprehend the scope of advancements in carrier aircraft engineering. Grumman's F4F *Wildcat* was the navy's standard fighter at the outbreak of U.S.-Japanese hostilities in 1941. It was by far the most widely used, capable, and reliable fighter of the first years of the War. Its characteristics were similar to that of the *Buffalo*, but it was slightly longer and 1400 pounds heavier.[58] Yet once war was declared, the aircraft industry made another jump in fighter aircraft technology. The *Wildcat's* successor, the Grumman F6F *Hellcat* (1943) was 33 feet long, had a wingspan of 42 feet (with wings folded, only 16 feet), and a maximum sustained engine rating of 2000 horsepower. Top speed was 323 knots. The heaviest version of the *Hellcat* was nearly 14,000 pounds, more than twice that of the

[57] Friedman, *Fighters Over the Fleet*, 444.
[58] Friedman, 446.

Buffalo. Vought's F4U *Corsair* had similar dimensions, weighed just over 12000 pounds, and was powered by the same Pratt & Whitney R-2800 engine as the *Hellcat*, with a 2000 horsepower power plant.[59] Over the course of the War, the *Wildcat*, *Hellcat*, and *Corsair* constituted the vast majority of the navy's carrier-based fighters. The technological changes that naval aircraft went through in roughly fifteen years were remarkable. Figure 1-1 illustrates the degree at which horsepower alone increased from naval aviation's earliest carrier fighters aboard *Langley* through those in service at the end of the Second World War.[60]

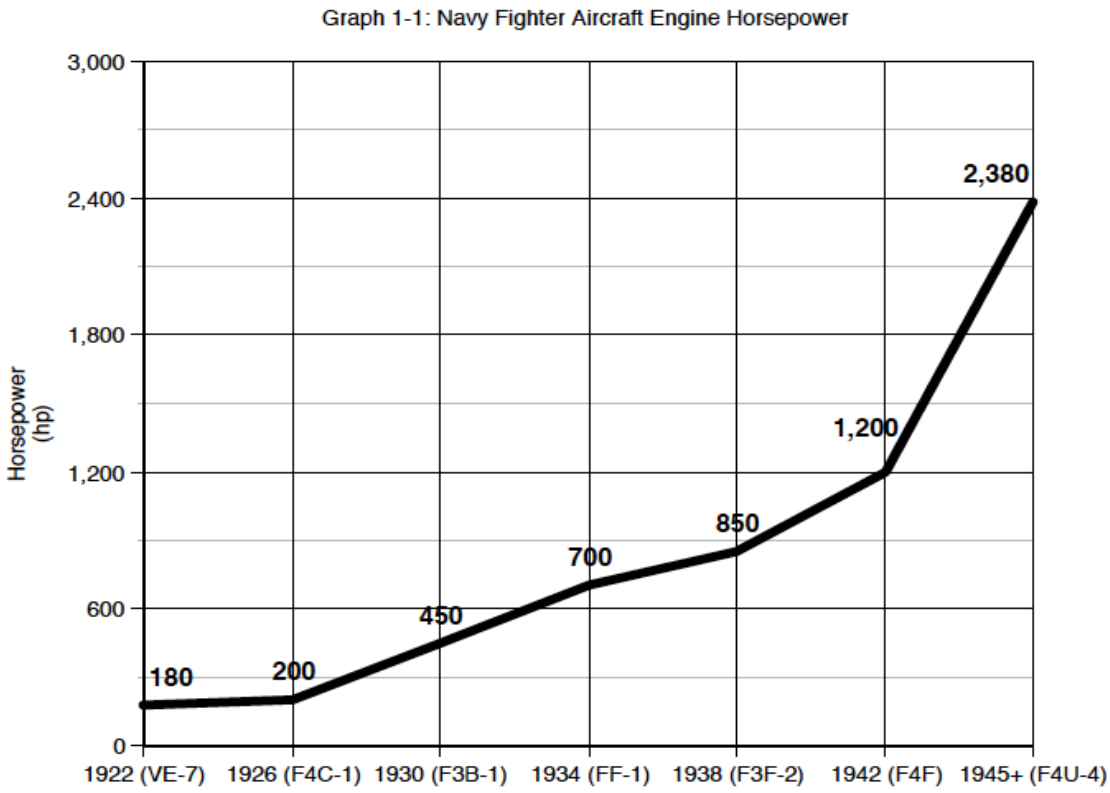

Figure 2-1: Navy Fighter Engine Horsepower

[59] Friedman, 447; Gordon Swanborough and Peter Bowers, *U.S. Navy Aircraft Since 1911* (Funk & Wagnalls: New York, 1968), 384.
[60] Figure 1-1 data is compiled from: Larkins, *U.S. Navy Aircraft 1921-1941* and Friedman, *Fighters Over the Fleet*.

Consider a young sailor enlisting in 1930 and learning the technical skills to become a carrier aircraft technician on the F4B-4 biplane fighter. Within a decade of service, he could be responsible for maintaining on an all-metal, monoplane F4F *Wildcat*, with an engine three times as powerful as what he apprenticed on. The learning curve was steep for the aircraft technician throughout the 1930s. Why the desire for better technical training or more proficient aircraft technicians did not have equal visibility as did the need for pilots remains unclear. One plausible explanation is that the navy's small number of aircraft and aircraft carriers did not seriously warrant more technicians than were already available. The low inventory of aircraft on both land and sea had been properly maintained thus far, and no serous contradictions to that fact existed before the period of naval expansion that was to come after 1939.

Based on the size of its aircraft carrier fleet throughout the interwar years, BuAer had managed to maintain its small amount of carrier-based aircraft with little difficulty. Not until the prospect of war became clear, did BuAer begin to serious consider expanding its capacity for training technicians and reconsidering carrier aircraft maintenance procedures. Change on an institutional level was necessary to counter the rising Japanese threat.

Acquiring more pilots and aircrew had traditionally drawn the most attention from lawmakers and navy leadership. Acquiring and training more enlisted technicians was not a regular point of contention. One would be hard pressed to find anything more than a cursory note in the "recommendations" section of the Chief of BuAer's Annual Report

to the Secretary of the Navy prior to 1939 that simply said, "Provide required increases in naval personnel to support the expansion program."[61]

While a peacetime navy was able to get by on two to three thousand designated aviation technicians during the last few years of the 1930s, it was only a matter of time before the threat of war forced the United States to radically change the complement and size of its aircraft and aircraft carrier force. The strength of naval aviation received a much-needed boost when President Franklin D. Roosevelt signed the Naval Expansion Act of 1938. With a stroke of FDR's pen, the navy was authorized to increase its air arm from 1,900 to a contingent of 3,000 aircraft. This required a corresponding increase in aviation personnel, especially rated technicians. Even though the cadre of experienced aviation technicians serving in the Fleet in 1938 was insufficient to meet the needs of a 3000-plane navy, the incoming Chief of BuAer, Rear Admiral John H. Towers, planned to gradually bolster his personnel numbers over a matter of years rather than months. In his eyes, and almost everyone else's at that time, another 1,100 aircraft would take years to acquire based on manufacturing practices of the 1930s. Little did Towers know that after December 7, 1941, he would be proven wrong on all accounts.

[61] U.S. Navy, *Bureau of Aeronautics Annual Report,* (Government Printing Office, Washington D.C.), 1935-1938.

Chapter 2: Expansion, Turf Wars, and Estimates

Historians of U.S. naval aviation in World War II have failed to recognize that skilled labor, or the maintenance of naval aircraft, played as critical of a role in the war as did the pilots and airplanes. Comparing only the technological, materiel, and tactical factors of the Japanese and American naval air forces fails to appreciate the behemoth task that the Bureau of Aeronautics and the Bureau of Navigation faced in filling the carriers and their squadrons with skilled aircraft mechanics and technicians.[62] Even with the surge of voluntary enlistments after Pearl Harbor, the navy still had difficulty fulfilling its manpower requirements. When a naval war with Japan became a reality, the navy was caught short in both materiel and trained manpower. There were only a few carriers to deploy, a limited number of carrier-based aircraft in service, and just a few thousand aviation technicians trained and ready to deploy.

These problems should not have come as a surprise. Just two years earlier, in 1939, the navy found itself scrambling to answer the question, exactly how many maintenance personnel would it need to successfully support a protracted naval war? An equally important second part to that question was from which pools of manpower was the skilled labor to be drawn. How these tasks would be managed was complicated; the fact that the Department of the Navy was not even sure which of its administrative bureaus was best suited to accomplish it made for an even more problematic situation. And leaving much of this business unfinished until after war is declared also brought with it serious difficulties.

[62] See introduction for more discussion on historiographical shortcomings.

Before World War II, the BuAer was responsible for the procurement of naval aviators and enlisted personnel. By law, BuNav, later renamed the Bureau of Personnel (BuPers), had ultimate authority with regards to selection and placement of both officer and enlisted personnel throughout the navy, but in matters of aviation personnel, the navy usually followed the suggestions of BuAer. Specifically, it was BuAer that made recommendations to BuNav "for the distribution in the various ratings of the enlisted personnel required by aeronautic activities," and "on all matters pertaining to aeronautic training."[63] This had been the standard practice since Congress authorized the establishment of BuAer on 12 July 1921. However, with the establishment of the Deputy Chief of Naval Operations for Air (DCNO Air) in August 1943, BuAer relinquished most of its responsibility for training, procuring, and assigning aviation personnel to the Fleet. Surrendering control of enlisted rating distribution and associated training was not the most desired outcome, but based on the enormous expansion of planes and aviation personnel, it was necessary. No matter who was in charge, the issue of determining how many technicians were required to keep the navy's aircraft operating had provoked intense discussion at the highest levels since the earliest days of BuAer. Funding was often based on personnel requirements. Providing a reasonable number to those authorizing appropriations had been part of BuAer's role in naval policy over the preceding two decades.

In December 1924, Rear Admiral William Moffett, Chief of BuAer, and members of his staff testified before Congress in hearings for the Naval Appropriations Bill of 1926. At the forefront of the discussion was the additional requirements in personnel

[63] Department of the Navy, *Bureau of Aeronautics Manual 1940* (Washington D.C.: United States Government Printing Office, 1940), 3.

with regards to introducing the concept of carrier aviation. At the time there was both a shortage of officer and enlisted men in the navy. Naval aviation was very young, but Moffett and his team had done their homework. When asked by Senator Frederick Hale of Maine how many additional enlisted men the aviation navy would require as more aircraft carriers were added to the fleet, Commander Laurence T. DuBose, one of Moffett's staff officers, answered, "You would need eight to ten men to the plane."[64] This number only increased later with advances in technology. According to *The Technicians' War,* the ratio of men to airplanes in 1945 varied between ten and twenty to one, depending on model and the level of maintenance required.[65]

By the mid 1930s—a decade after Moffett had argued that more aircraft mechanics would be required to service aircraft—the navy had accepted the aircraft carrier as being a significant component of the Fleet's striking power[66] In 1936, the United States had three operational carriers, the *Langley, Lexington,* and *Saratoga,* plus the *Ranger* was under construction. In addition, *Yorktown* and *Enterprise* had just been authorized for construction by Congress under the statutes of the Vinson-Trammel Act of 1934. By 1940, the navy's procurement goal for large fleet aircraft carriers was a total of

[64]Office of Deputy Chief of Naval Operations (Air), "Aviation Personnel, 1911-1939," in *United States Naval Administration in World War II*, vol. 21 (Washington D.C.: U.S. Government Printing Office, 1959), 210.; DuBose (1893-1967) retired as a full Admiral in 1955. Source: https://navy.togetherweserved.com. accessed 7/16/18;

[65] Headquarters, Naval Air Technical Training Command, *Technicians' War: A Picture Story of U.S. Naval Air Technical Training Command* (Atlanta, GA: Albert Love Enterprises, 1945). This estimate is not based solely on carrier technicians. It included land-based aircraft squadrons which operated much larger, multi-engine aircraft that would require more maintenance personnel. The ratio aboard aircraft carriers was closer to 10:1, which included non-aircrew aviation maintenance officers. See Friedman, *U.S. Aircraft Carriers,* Appendix E.

[66] For a more thorough discussion on the topic of aircraft carrier policy in relation to battleship development during the interwar years, see Charles Melhorn, *Two-Block Fox: The Rise of the Aircraft Carrier, 1911-1929* (Annapolis, MD: Naval Institute Press, 1974).

eighteen, excluding the smaller cruiser-conversion light carrier and the even smaller escort carriers that were being contemplated.

By the mid-1930s, the navy had standardized aircraft inventory aboard aircraft carriers. Large carriers such as *Yorktown* (CV-5) and *Enterprise* (CV-6) embarked four squadrons: one fighter, one dive-bomber, one scout-bomber, and one torpedo-bomber. Each squadron was authorized eighteen aircraft for a total of seventy-two airplanes per carrier.[67] Smaller 'escort' and 'light' aircraft carriers (CVE and CVL) were two to three years away from entering service, as was the enormous *Essex* class carrier that would have a complement of ninety aircraft to begin. In the summer of 1941, the navy's inventory of aircraft, both carrier and land-based reached 4,000. That number would double in less than a year. As impressive as that number was, simply having planes parked on ships or at airfields did nothing for the country's defense without personnel to fly and maintain them.

The entire January 1942 issue of *Flying and Popular Aviation* was dedicated to U.S Naval Aviation.[68] The U.S. Navy officers writing the articles were adamant that machines were not enough to meet the Japanese threat that was rising in the West or Hitler's push toward the Atlantic in the east. The expansion of the navy's team of skilled aircraft technicians would have to match that of the growth in numbers of pilots and aircraft in keeping the fleet combat ready.[69]

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[67] Aircraft complement aboard each aircraft carrier would vary throughout the war. The average for an aircraft carriers of *Yorktown* size was between 72 and 78 aircraft. As aircraft technology changed and carrier decks increased in size, the number of aircraft on board larger carriers such as *Essex* would reach ninety to one hundred by 1943. See Friedman, *U.S. Aircraft Carriers*.

[68] *Flying and Popular Aviation*, January 1942.

[69] Articles and comments within this issue of *Flying and Popular Aviation*, located in USNA's Nimitz Library, were submitted and edited in the fall of 1941 prior to the attack on Pearl Harbor, even though the publication date is January, 1942. Articles include "The Power Plant" by Rico Botta, "Radio" by G.B. Hall, "CV-The Carrier" by William Halsey, "The Naval Air Station" by Ben Morelli, "The Naval Aircraft

Aircraft maintenance before World War II involved a plethora of tasks. Broadly speaking, it included servicing of airplanes, their engines, and component parts. Aboard ships and Naval Air Stations, technicians did not attempt to perform serious repair work or overhaul such as complete disassembly and reassembly of aircraft engines. Fleet technicians' or maintainers' daily routines encompassed regular inspections of aircraft structures and their component parts to ensure that the airplane was safe to fly. Major overhaul was not a regular occurrence at sea. Typically, aircraft overhauls only occurred only when the damage was irreparable onboard ship, or the aircraft had reached a pre-determined number of flight hours which rendered the parts and airplane unsafe until complete overhaul was accomplished. Overhaul and major repair work was normally completed at facilities ashore, such as the Naval Aircraft Factory.[70] The quality of work done at the shore-based facilities by technicians directly affected the performance of aircraft at sea.

One of the primary tasks for an aircraft mechanic aboard a carrier was to "find and correct defects before they can cause serious trouble."[71] Aviation units operating on carriers had to be self-sustaining, capable of making various small jobs such as propeller changes and minor repairs as needed. Most of all, their highest priority was to ensure preventative maintenance such as engine oil changes and corrosion control was completed regularly. If a plane suffered major mechanical trouble at sea and was no longer flyable, it had a ripple effect. A plane that could not fly reduced the combat operating capability of the squadron and became an obstacle in everyday operations. The

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Factory" by E. M. Pace, "Maintenance" by V.H. Schaeffer, and "Naval Operations and Aviation" by Harold M. Stark.

[70] V.H. Schaeffer CDR, "Maintenance," *Flying and Popular Aviation*, January 1942, 132.

[71] Schaeffer, 132.

logistics of making room in the hangar bay for an airplane that could not fly interrupted the daily flight operations of the entire ship. Storage and parking space was limited onboard ships. There was little room for "hangar queens." Effective preventive maintenance and battle-damage repair by squadron mechanics was thus essential to sustain operational efficiency.[72]

These 'back-stage' actors had to be qualified to maintain essential and highly complex mechanical systems at all times, which included engines, airframes, hydraulics, armament, ordnance, communications, and electronics during deployment. Work that had been previously done at shore facilities now had to be completed on the ship. Before the U.S. entered the World War II, squadron technicians were initially trained at the navy trade schools and received follow-on, more advanced training during shortened tours of duty at the shore-based overhaul facilities, such as the Naval Aircraft Factory in Philadelphia, Pennsylvania[73]. Many of the enlisted technicians were trained in multiple facets of repair and overhaul. This made them more like "jacks of all trades" rather than a sailor identified by their specialty rating.[74] Learning the skillset needed to work on naval aircraft was acquired through multiple tours of duty inside advanced engineering facilities where naval aircraft underwent overhaul.

Assembly and Repair shops were the mainstay of the navy's aircraft overhaul program throughout the interwar years. The navy's methodology of using them as advanced technical training schools was suitable for aviation maintenance at that time. The Naval Aircraft Factory had been one of the more proven feeder systems of technical

[72] "Aviation Maintenance," n.d., Carriers Collection, Box 17, NHHC.
[73] Trimble, *Wings for the Navy: A History of the Naval Aircraft Factory 1917-1956*, 211.
[74] Schaeffer, "Maintenance," 133.

maintenance for the Fleet throughout the early interwar years. Producing a surplus of trained labor in aircraft systems was the hallmark of the Naval Aircraft Factory.[75] However, as the production of aircraft and spare parts went into overdrive on the eve of the war, it was evident that the lengthy process of training an aircraft mechanic on-the-job had become a liability. This method of technical training would be unable to keep pace with the fast-paced demands of naval aircraft operations once the U.S. entered the war.

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Prior to 1939, a relatively small unit within the Bureau of Aeronautics was able to manage the supply of ratings and fleet aviation personnel. This department was designated the Flight Division. In 1939 the designation changed to the Naval Personnel Section of the Administrative Division, remaining so until it was officially renamed the Personnel Division in 1945.[76] According to the 1940 *Bureau of Aeronautics Manual*, it was the responsibility of the Personnel Division to determine the requisite number of ratings and their distribution throughout the Fleet.[77] The Personnel Division was tasked with the "Preparation of recommendations for the distribution in the various ratings of enlisted personnel required for aeronautic activities." Additionally, it was also responsible for "maintenance of commissioned and enlisted complement charts of all

[75] E. M. Pace, "The Naval Aircraft Factory," *Flying and Popular Aviation*, January 1942, 208.
[76]Bureau of Aeronautics, "Aviation Personnel and Training," in *United States Naval Administration in World War II*, vol. 12 (Washington D.C.: U.S. Government Printing Office, 1959), 1–2.;For clarity, only "Personnel Division" will be used to identify this division throughout the rest of this document, no matter what timeframe is being discussed.
[77] A "rating" is another term for an enlisted sailor who has qualified as proficient in a specific field of labor or warfare, i.e. "Radioman", "Electrician's Mate", or "Aviation Metalsmith."

aircraft operating units, aircraft carrier and tenders, and aeronautic shore establishments."[78]

The BuAer Personnel Division did not operate in a vacuum. Coordination with the Maintenance and Plans Division would help determine future requirements as new technology came on line. It was the Plans Division that made "recommendations to the Chief of the Bureau as to numbers of new aircraft of each type" and "for the distribution and organization of available aircraft and the assignment of aircraft squadrons and detachments."[79] The Personnel Division was the primary source for ratings numbers and personnel distribution, but each report given to the Chief of the Bureau considered the views of other administrative units. Within the BuAer Personnel Division, there was both a Reserve and Regular Navy (non-reservists) Section. Each managed the distribution of its own personnel throughout the Fleet. The responsibilities of the Reserve component of the Personnel Division were outlined in a memo to Captain George D. Murray, Director of the Personnel Division, dated August 18, 1939: "The section makes recommendations to BuNav in regard to enlisted men required, and the distribution of stationkeepers, numbers and rates of men, and officer compliment requirements in Naval Reserve organization squadrons. Squadron organizations, as shown on copies of personnel reports, are scrutinized for proper balance of rates …."[80] According to the official history, the section that managed the regular-duty (non-reservists) personnel was responsible for the same aspects of the active duty enlisted force. "Correspondence files on personnel matters indicate comparable participation on the part of the Personnel

[78] *Bureau of Aeronautics Manual 1940*, 8.
[79] Ibid., 7.
[80] Office of Deputy Chief of Naval Operations (Air), "Aviation Personnel, 1911-1939," 97.

Division in matters affecting regular navy personnel of the aeronautic organization."[81] Ultimately, BuNav had to agree on the personnel requests made by BuAer's Personnel Division. However, since the Moffett era, BuNav routinely defaulted to BuAer's requests when issuing orders to aviation-rated personnel.

On 9 September 1939, a week after war had broken out in Europe, President Roosevelt ordered the navy to raise its inventory of enlisted men from 110,000 to 145,000. Less than a year later, on 14 June 1940, FDR ordered an expansion of naval aircraft numbers from 3,000 to 4,500 planes. The following day he increased the goal to 10,000. Four days later FDR boosted the requirement to 15,000 aircraft.[82] The impending rise in the level of administrative workload that accompanied such a buildup was too much for BuAer. Captain Murray recognized the potential for an administrative disaster within the Personnel Division. Having recently served on the Aviation Personnel Board of 1939 (commonly referred to as the Horne Board) as RADM Frederick J. Horne's senior ranking member, Murray was keenly aware of the requirements associated with an expanded aviation navy.

The primary focus of the 1939 Horne Board was solving the problem of meeting the need for pilots associated with an increase to a 3000 aircraft navy. Yet, there was some minimal discussion regarding procurement of enough skilled enlisted technicians to meet the increased demand. Much of the dialogue focused on injecting the Naval Reserve component with trained technicians to meet the demand anticipated in the event

[81] Ibid.
[82] The "Two Ocean Navy Act" or "Vinson-Walsh Act" was the largest single procurement bill in U.S. history. It increased the overall size of the Navy by 70%, including the requirement for 15,000 naval aircraft. It was enacted into law on 19 July 1940.

of war. The board's discourse was influenced by the expectation of additional large increases in aircraft force levels over the coming six years.[83]

By June 1940, a 3,000-airplane force was no more than a memory. President Roosevelt's requirement to increase the inventory of airplanes to 15,000 disrupted all the planning Murray and Horne had done a year earlier. Murray quickly pointed out in a memo to BuAer Chief, Rear Admiral John H. Towers and BuAer Assistant Chief, Captain Marc A. Mitscher, that his division staff size was the same as it had been in 1935 and would never survive the massive increase in workload with the upcoming expansion. At that time, the Personnel Division consisted of eight officers and seven stenographers (clerks) who managed an inventory of 800 aviators and 12,500 enlisted men. By September 1940, his staffing had only increased to fourteen officers and fourteen stenographers, but they were handling 2,150 aviators and an enlisted detail that would quickly reach 38,000 by October 1940. He respectfully informed his bosses that the Personnel Division would soon be unable to keep up with its assigned administrative duties.[84]

Captain Murray suggested two possible courses of action: BuAer could transfer its entire Personnel Division to BuNav, or BuNav could surrender its role in the administration of aviation personnel completely. The latter option would involve BuAer assuming office staff from BuNav workspaces. The former would include posting a senior BuAer officer in BuNav as a permanent liaison.[85] Murray did not express a preference for one course over the other, but his anticipation of future personnel

[83] Frederick J. Horne, "Report of Board Convened to Investigate and Report Upon the Regular and Reserve Aviation Personnel of the Navy and Marine Corps," December 22, 1939.
[84] Bureau of Aeronautics, "Aviation Personnel and Training," 1959, 99–100.
[85] Ibid., 99-101.

administrative requirements was justified. Murray recognized the obvious administrative implications of a massive increase in naval aircraft for both the BuNav and BuAer, and sought to avoid the chaos that was bound to accompany a rapid surge of personnel and materiel. Yet, neither Towers nor Mitscher showed any desire to expand or reorganize the Bureau of Aeronautics.

Archived documents record that both Mitscher and Towers answered Murray's memo with penciled-in comments in the margin. Mitscher recommended to "stand pat" and make no changes to procedures for fear of having to revamp the BuAer Manual and possible laws governing the actions of either Bureau. Towers amplified Mitscher's comments, stating he preferred to keep the arrangement as-is. He did not support "relinquishing all control" to BuNav nor did he want to cut BuNav out of the loop completely. Towers felt that the present agreement between himself and BuNav Chief Rear Admiral Nimitz was satisfactory. In the marginal notes, Towers instructed Murray to "build up your organization as needs indicate."[86] On paper, Towers did not indicate that his organization, as it currently stood, needed any restructuring. But later, changes within the administration of personnel would prove that he was either too proud or too complacent to admit that the way that BuAer handled administrative operations in 1940 was insufficient to meet the impending demands of the aviation expansion program.

Ultimately, increases in planes and personnel requirements forced the Personnel Division to restructure. On 28 December 1940, Mitscher issued a statement to all Bureau personnel that the division would be reorganized beginning 2 January 1941, "in order to

[86] Ibid., 102.

meet the needs of the expanded flight training program and to coordinate the planning and personnel requirements for the increased Aeronautical Organization …"[87]

A Planning and Training Section was established within the Personnel Division that supervised training activities along with managing enlisted allowances. Officer and enlisted detailing each had its own section. In addition, by July 1941, the Chief of Naval Operations (CNO), Admiral Harold Stark, was well aware of the increased manning and training requirements. He made a formal request to Towers to take any and all necessary action to assure that the training of officers and enlisted, flight and technical, was coordinated. The Bureau of Aeronautics was to make the appropriate adjustments necessary to ensure the "effective coordination of all phases of aviation training and the expeditious accomplishment of the planned expansion of naval personnel."[88]

Towers, having learned a thing or two about what it meant to play the politics of naval bureaucracy from his time as Moffett's chief assistant, could not have missed the signs that Nimitz was next in line for a promotion and a major fleet assignment. There had been previous struggles between the two Bureau Chiefs over personnel issues, primarily regarding pilots. When the navy was authorized to increase their aviator corps to 3,000 regular naval aviators and a minimum of 6,000 in the Naval Reserve, the relationship between Nimitz and Towers was placed under greater strain. Nimitz was evidently reluctant to lose more officers to the flying navy when he was under pressure to continue filling surface and submarine officer billets. In 1939, there was only a limited national emergency based on events in Europe and Americans were not flocking to the recruiting stations just yet. Towers, in a shift from his younger days, was becoming more

[87] Bureau of Aeronautics, "Aviation Personnel and Training," 1959, 102.
[88] Ibid., 103.

of a bureaucrat as he settled into his position as BuAer Chief. He had learned from one of the best, Admiral William Moffett, and was seeking approval for more naval air stations and more schools. The tension between Towers and Nimitz could have resulted from intra-service rivalry between aviators and non-aviators, but it might also have simply been a personality clash. One of Nimitz's aides recalled that "he just didn't care much for Admiral Towers," and his methods of doing business.[89] The feuding between the two admirals would continue for the better part of the War, but neither would permit it to get out hand and jeopardize the navy's mission although at times, it came uncomfortably close to doing so.

In one instance during August 1940, Towers had asked Nimitz to permit a select number of recent graduates of the Aviation Metalsmith School to stay for a follow-on assignment as instructors. Nimitz refused Tower's request. Nimitz's task as Chief of BuNav was to get trained technicians on to the ships and squadrons at sea. Holding back even a few sailors for instructor duty could have detrimental effects on the readiness of the Fleet. Nimitz denied Towers' request and did his best to keep filling the Fleet with trained technicians.[90]

A few months later, in November 1940, Admiral James O. Richardson, Commander-in- Chief of the United States Fleet (CinCUS) made it known to the Bureaus that the Pacific Fleet was still lacking technical ratings amongst its aviation units. These units needed maintenance personnel, but neither BuNav nor BuAer could fill the present shortfall with the system operating as it was.[91] The navy's technical training program,

[89] As quoted in Reynolds, *Admiral John H. Towers: The Struggle for Naval Air Supremacy*, 294.
[90] Memorandum from Chief, BuAer to Chief, BuNav, 23 August 1940, RG 24, NC 70, Box 610, NARA I,
[91] Ibid.

still under the cognizance of Towers was insufficient to meet the demands of the navy's massive increase in airplanes, ships, and squadrons.

Unfortunately, Admiral Horne's reports spent little time on concerns over the shortage of aviation technical ratings in the Fleet. The majority of Horne's suggestions were focused on pilot training and officer problems, which was the original reason for appointing the Board. Even more interesting is the fact that much of what Horne released as his official report looked very similar to the inputs that Towers had sent him in memo format on 27 September 1939. The answers that Horne provided regarding which ratings were required, advancement in rank, and rotation of duty stations all followed BUAERs suggestions and were facilitated by Murray and other BuAer officers interviewed by the Board.[92] When Towers responded to Horne's inquiries, the President had only authorized an increase of the navy's enlisted by 35,000 and an aircraft increase to 3,000 planes. Even this strained the existing administrative apparatus of BuAer. Nevertheless, Towers believed the Bureau could handle it.[93]

He strongly advised that much of the technical training be handled within the overhaul facilities themselves. He also indicated that those trained in facilities within the Continental U.S. would be best suited to take their expertise to repair facilities outside of the border, such as Midway Island.[94] There was no mention of a possible increase in numbers, nor any recommendation as to from where BuAer would acquire more sailors other than from the general pool of enlisted personnel already authorized by Congress. Even after the expansion was authorized, as recommended in the second Horne Board

[92] Bureau of Aeronautics, "Aviation Personnel and Training," 1959, 115.
[93] Ibid., 102.
[94] See Memorandum from Towers to Horne, "Personnel in the Naval Aeronautics Organization, Recommendations Concerning," September 27, 1939, RG 72, Box 189, NARA II.

Report of November 25, 1940, there was little discussion of where and how the navy would procure, train, and distribute technical aviation ratings throughout the Fleet.[95] Congressional authorization of enlisted strength within the navy was insufficient to satisfy the enlisted personnel requirements of BuAer, but unfortunately Horne either did not recognize this or, more likely, regarded this to be a general personnel problem that had to be addressed by the navy as a whole. His first report in January 1940 claimed that the required enlisted aviation ratings could be drawn out of the general labor pool of the enlisted navy. "The situation [Enlisted men of the navy] can be met, and there can be made available sufficient enlisted men of the Regular Navy to meet the demands of the aeronautic organization…"[96]

The findings of the Horne Board did not identify the problem of procuring a sufficient number of aircraft technicians as a numbers issue, but rather as a training concern.[97] The Report reflected Towers' suggestion that the present authorized aviation technical ratings be continued, but also recommended that specific entries should be made in the service records of any enlisted men who held special aviation experience. Designations such as aircraft-engine overhaul expert, propeller overhaul specialist, aircraft instruments repair technician, aviation welder, bomb-sight mechanic, aircraft painter, radioman qualified in aircraft, and automatic-pilot technician were all included in the list of twenty-two specific qualifications.[98] While not at the forefront of either BuAer

[95] Second Horne Board report, pg. 19-20 as cited in Bureau of Aeronautics, "Aviation Personnel and Training," 1959, 137.
[96] "Aviation Personnel Board 1940-1941," para. 50. Herein referred to "Aviation Personnel Board 1940-1941"
[97] Bureau of Aeronautics, "Aviation Personnel and Training," 1959, 137.
[98] "Aviation Personnel Board 1940-1941," para. 246.

or the Horne Board's concerns, it was evident that those already trained in the skilled-labor of aircraft maintenance were a resource that should not be overlooked.

The latter part of Horne's report made significant mention of Reserve enlisted men filling the future needs of the aviation navy. It also discussed the potential of filling the ranks with ex-servicemen who held aviation ratings or those currently holding civilian occupations in the commercial aircraft industry. The intent was to recruit individuals to the Naval Reserve who could quickly qualify as an aviation technician. The Board also believed that a large number of trained aviation technicians would be available for reserve duty in the coming years due to the rapid expansion of aviation in the commercial sector over the last decade. However, this would not solve the immediate problem of filling the ranks with technical expertise. The Board wisely suggested that in order to obtain a satisfactory number of qualified maintenance personnel in the Reserve units, additional training facilities and schools, along with the appropriate funds for sustainment, should be made available immediately.[99]

By the beginning of 1941, the lack of experienced instructors at both the pilot and technical schools had also become obvious. Neither Nimitz's nor Towers' organizations were able to remedy this problem. However, what mattered most to the decision-makers in Washington was sustaining efficiency with able bodied sailors to fly and maintain the swelling aircraft fleet. Admiral Stark made it clear to Nimitz and Towers that withdrawing experienced sailors from the fleet units to serve as instructors was unacceptable. Stark informed Nimitz directly via confidential memo that any more reductions of aviation petty officers assigned to tactical aviation units would be looked

[99] Ibid., paras. 261–263.

upon unfavorably.[100] The CNO did not want his tactical units losing experienced maintenance personnel to the training commands under BuAer's charge.

Nimitz was aware of the tug-of-war between the needs of the aviation and Regular Navy, but filling the personnel quotas of sea-duty aviation units under the CNO's cognizance took priority over shore-based aviation facilities delegated to BuAer's control. By 1 March 1941, aviation commands at sea were 100 percent manned, yet shore-based facilities were only staffed at 65 percent. This meant that BuAer had to make do with just 9,115 manned billets of the nearly 13,660 requested, a labor shortage of 4,545 personnel.[101] Stress on the overhaul and repair facilities had grown since the aircraft expansion had been authorized in June 1940. On 3 April 1941, Nimitz requested that the Commanding Officers of Naval Reserve Air Bases (NRAB) within the Continental United States train as many aviation machinist's mates and aviation metalsmiths assigned to their commands as possible in aircraft and aircraft engine overhaul procedures to mitigate the shortage in mechanics. He did not call for the base commanders to affect negatively day-to-day operations or recall Reservists from fleet assignments, but the technicians that were to be trained in overhaul work should come from within the Reserve air bases' present complement of enlisted men.[102] The dilemma of getting experienced technicians to the Fleet and overhaul shore facilities was adding to the predicament of training enough aircraft technicians for fleet squadrons. The pressure

[100] Memorandum from Chief of Naval Operations, to Chief, BuNav, 12 February 1941, as referenced in Bureau of Naval Personnel, "History of Enlisted Personnel Activity," in *United States Naval Administration in World War II* (Washington D.C.: U.S. Government Printing Office, 1959), 122.
[101] Bureau of Aeronautics, "Aviation Planning," in *United States Naval Administration in World War II*, vol. 5 (Washington D.C.: U.S. Government Printing Office, 1959), 32–33.
[102] W.H. Heiser, *U.S. Naval and Marine Corps Reserve Aviation, Volume I, 1916-1942 Chronology* (McHenry, IL: Dihedral Press, 2006), 134.

of making trained aviation technicians readily available was becoming a common thorn in the sides of both Bureau Chiefs.

Even after Horne's report was submitted and supposedly provided answers as to how the navy would meet the personnel needs of an enormous air arm, the problem of determining the appropriate number of billets and where to assign those billets still was not solved. Instead, most of the creative talent was put to work solving the question of how many pilots would be needed as the number of aircraft increased and where the pool of cadets would come from. BuAer was focused on aircraft and pilots because no one had any experience in procuring, training, and distributing the vast number of technical aviation ratings such a large fleet of aircraft required. BuNav was well versed in detailing sailors to the few ships and the squadrons that were in existence during the interwar years, however neither Bureau comprehended the massive effort it would take to maintain the thousands of airplanes that would be operating from the flights of aircraft carriers in a few short years.[103]

As Chief of BuAer, Towers knew enough to not alienate BuNav. By law, the two Bureaus were forced to work together on aviation personnel distribution and a feud between the Bureaus would only exacerbate the shortage in technical ratings. Not wanting to burn any bridges, but desiring complete control over aviation personnel issues, Towers voiced his opinion in a letter to the Secretary of the Navy, ensuring it went through both Nimitz and Stark beforehand:

[103]The Navy had forecast a capability to operate 13,981 carrier-based aircraft by December 31, 1945 according to the current strength of the fleet plus the number of aircraft carriers and aircraft in production per a BuAer briefing given in July 1944. See "The Program for Naval Aviation," July 5, 1944, 5, NAVAIR Collection, Box 120, NHHC.

> …the functions of procurement and distribution of aviation personnel can be handled satisfactorily under the present system [BuNav and BuAer coordination]. On the other hand, it is strongly felt that the marked improvement in training of pilots and technical aviation ratings could be effective through the centralization of all functions pertaining to these matters under one Bureau. For reasons above, it is believed that the Bureau of Aeronautics should be designated and the Cognizant (*sic)* Bureau.[104]

It only took the Secretary of the Navy, Frank Knox, three days to grant Towers' request. On 6 October 1941, he approved a reorganization of BuAer that included reducing the number of major divisions to five, "Personnel and Training" among them. By November, Personnel and Training was split into two separate Divisions, each under the auspices of a separate Director. Even in the new system, however, BuNav still maintained a segment of control in manning the aviation community. Although BuAer was given cognizance over all aviation training, controlling the ebb and flow of personnel within the aviation navy was still a joint effort between Towers' and Nimitz's Bureaus.[105]

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In 1940, the United States simply did not have the active duty manpower to fill the ranks of the aviation navy with qualified technicians. However, the Naval Reserve forces did have a significant number of trained personnel—a fact that the Horne Board had specifically pointed out. Ultimately, it was BuNav which made the call for an involuntary mobilization of reservists in July 1940. Nimitz directed the Commandants of each Naval District to ensure any Fleet Reservist with the following ratings were brought

[104] Bureau of Aeronautics, "Aviation Personnel and Training," 1959, 104.
[105] Ibid., 104-105.

back to active duty: Radioman (Qualified in Aircraft), Aviation Machinist's Mate, Aviation Metalsmith, Aviation Carpenter's Mate, and Aviation Ordnanceman. The two other Reserve components of the navy that were in existence at that time, the Organized Reserve and the Volunteer Reserve, were not subject to the compulsory mobilization.[106] In the summer of 1940, it still appeared that both Nimitz and Towers believed that the limited mobilization of Fleet Reserve technical ratings would suffice.

In June 1940, when President Roosevelt ordered the increase of naval aircraft to 15,000, Knox, Towers, and Nimitz must have realized the dire straits that they were about to be in. On 5 October 1940, Knox sent a dispatch to District Commandants that read, " … call retired enlisted men who may be usefully employed … no volunteer reserves will be sent to active duty for less than one year …"[107] Towers followed Knox's lead two weeks later and recommended that BuNav retain the squadron personnel of the Organized Reserve "in a skeleton status at their home Naval Reserve Aviation Base and … enlisted personnel be made available for infiltration into the aviation component of the Fleet and Shore establishment."[108] Towers' recommendation was endorsed by Admiral Stark, CNO. Then on 17 October, Towers formally recommended that BuNav mobilize the Organized Reserve at the earliest date possible. Towers firmly believed that the only way to solve the problem of mustering enough trained aircraft technicians was through mobilization of veteran technicians of the interwar years.[109] Unfortunately, rapid

[106] Bureau of Aeronautics, "Aviation Personnel and Training," 1959, 165.
[107] Ibid., 166.
[108] Towers to Nimitz, October 12, 1940 as quoted in Bureau of Aeronautics, "Aviation Personnel and Training," 1959, 167.
[109] Ibid., 168.

advances in technology would complicate matters even more, making Towers' plan insufficient to alleviate the shortage of maintenance personnel.

Nimitz quickly complied with Towers' recommendation to mobilize the Organized Reserve by ordering aviation squadrons to do so the following week. Nimitz's plan structured the mobilization of squadrons in thirds with 7 November 1940; 1 December 1940; and 1 January 1941, as the intervals for District Commandants to reach their milestones. The navy was trying to alleviate some of the strain on the commercial aviation industry by activating the Reserve units in thirds. BuNav directed that any Organized Reservists employed in the airline industry were to be mobilized in the November or January rounds. This gave the men an opportunity to submit their resignation from the Reserves, accept a discharge, or request a transfer to voluntary classification as active duty. Every effort was made to minimize the impact on the commercial airline industry since commercial airlines were considered vital to national defense.[110]

Aircraft technicians who were employed as civilian aircraft mechanics at Naval Air Stations and naval aircraft repair facilities created another quandary for the navy. A year earlier, BuNav had assured the District Commandants responsible for such facilities that those employees were considered "key" men, and that they would not be mobilized until sufficient replacements were hired and trained. However, as word of the aircraft buildup to 15,000 came down, Nimitz relented and warned the Commandants in August, that this policy would not most likely be negated based on current events. He directed

[110] Ibid., 169.

them to ensure that all naval activities under their jurisdiction took appropriate steps to "train replacements for the Fleet Reservists still employed in a civilian capacity."[111]

The navy also set up a specific board to review those who were on the Organized Reserve list, where they were employed, and what their jobs entailed. Admirals Nimitz and Towers were concerned about damaging the operations of aircraft manufacturers and airlines and other industries that were considered critical to defense. After reviewing each individual's employment records, the board decided which Organized Reservists would be activated. By November 1940 the situation had become critical. Secretary of the Navy Knox released a message that authorized BuNav to order members of the Volunteer Reserve back to active duty, with or without their consent.[112] Finally, the tide had finally turned on the relative banal service requirements of the Naval Reserve forces. But the question remained, would it be enough to alleviate the shortage of trained aircraft maintenance personnel in the Fleet?

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Murray's concerns over managing the personnel distribution of fleet aviators and technicians were valid in 1939. Despite the fact that there was a national emergency with Europe on the brink of war, BuAer and BuNav saw little need to deviate from the *status quo* regarding distribution of technical aviation ratings throughout the Fleet. Fleet carrier aircraft were similar, if not the same models that were flying throughout the late 1930s. Recalling reservists provided temporary relief from the problem, but by 1942, much of the relief had been exhausted. As convenient as it may be to try and fault Towers or

[111] Chief, BuNav to All Commandants of Naval Districts, 20 August 1940, as noted in Bureau of Aeronautics, "Aviation Personnel and Training," 1959, 170–71.
[112] ALNAV 114, 20 November 1940; also noted in Bureau of Aeronautics, "Aviation Personnel and Training," 169.

Nimitz for not adjusting to the future needs of the navy, the navy was still flying Grumman's F3F (1938) biplane fighter when the second Horne Board Report was published. Only a limited number of the Brewster F2A *Buffalo* monoplane fighters were launching from carrier decks at that time. Both aircraft were products of mid-1930s engineering, delivering little in the way of tactical or technological advancements. Grumman was in the process of delivering a more modern, technologically advanced monoplane fighter. Yet, it was not until December 1940 that the navy took delivery of its first Grumman F4F *Wildcat*. Only 179 additional were delivered to the Fleet throughout the following year of the war. Production did not reach peak level until 1942.[113]

Navy fighter squadrons had been operating on aircraft carriers for over a decade. There did not appear to be much concern over the numbers of trained technicians in pre-war planning other than what Captain Murray had expressed. Obviously, actions taken by Towers to remedy the situation fell short of expectations. In an unsigned memorandum to Towers in May 1942, most likely from someone in the Office of the Assistant Secretary of the Navy for Air, the Bureau's ability to handle personnel planning is highly criticized. The memo, which is based on an interview with Mr. H. C. Emery, of the Office of the Assistant Secretary of Navy for Air, stated:

> The Planning Division [of BuAer], though it has comprehensively, thoroughly and creditably fulfilled its functions in regard to material planning, exercises little or no control of the Personnel, Training, and Flight Divisions. It has apparently never occurred to anybody that planning of this nature is equally important with

[113] "Bureau of Aeronautics Analysis of Naval Production Airframe Contracts," August 1945, Carriers Collection, Box 13, NHHC.

> material planning… If Naval Aviation is to meet its wartime responsibilities properly, this obvious deficiency should be corrected immediately.[114]

The primary focus of the navy was on material and technology during the pre-war period, rather than on the skilled labor requirements necessary to employ such weapons. Neither Towers, nor Nimitz had made any significant changes in response to the massive requirements for skilled labor among the enlisted ranks in naval aviation squadrons.

It would be incorrect to say that the war caught BuAer by surprise, since plans were in place by 1939 to meet the requirements of a 3,000-plane navy, thanks to George Murray.[115] Estimates of how many enlisted personnel were needed to support naval aviation were constantly updated by Towers and his staff through yearly budget estimates and annual reports. In his response to the Horne Board's questions in September 1937, most likely *via* Murray's inputs, Towers put forth a six-year estimate on how many enlisted personnel would be required to support a 3,000-plane navy. These numbers did not reflect the specific number of technical aviation ratings such as Aviation Ordnancemen or Aviation Machinist's Mates, but rather a general number of both technicians, supply, and administrative personnel to support the aviation fleet. Yeoman, Supply Clerks, and Boatswain's Mates worked alongside aircraft mechanics and

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[114] Memorandum for Admiral Towers, 19 May 1942, *unsigned,* as quoted in Bureau of Aeronautics, "Aviation Personnel and Training," 1959, 207.

[115] Little else is mentioned about George D. Murray in the administrative histories of the Bureau of Aeronautics. In March 1941, after his tour at BuAer, he was given command of *USS Enterprise* (CV-6). Murray served as its Commanding Officer during Battle of Midway. After Midway he was promoted to Rear Admiral command and was made Commander, Carrier Division Three and Task Force 17, which included *Hornet* until she was sunk. In 1943 he was assigned as Chief of the Naval Air Intermediate Training Command in Pensacola. He retired in 1951 as a full Admiral. For additional details of his wartime experiences, I recommend William Tuohy, *America's Fighting Admirals: Winning the War at Sea in World War II*, (Zenith Press, St. Paul, MN), 2007.

Radiomen on board aircraft carriers and Naval Air Stations. It was not an exact science, but the BuAer Personnel Division did its best to predict the requisite numbers of sailors based on numbers of aircraft available to the Fleet. From the following table, it is apparent that Towers even understood the gradual increase in manpower required each year as the number of fleet aircraft increased to 3,000.[116]

Table 2-1: BuAer Enlisted Aviation Personnel Estimate 1937 [117]

Year	Enlisted Personnel in Aviation Service Requirement
1940	20164
1941	24021
1942	27978
1943	29518
1944	32133
1945	33110

Following President Roosevelt's authorization for a 15,000-plane navy, BuAer drastically increased its requirement to a total projected force of 120,533 enlisted aviation personnel.[118] The new aircraft were scheduled to enter service on a gradual basis, over a multi-year timeline culminating in 1945. This number did not include enlisted pilots and

[116] See Table 1.
[117] Chief BuAer to Senior Member Aviation Personnel Board, "Personnel in the Naval Aeronautical Organization, recommendations concerning." RG 72, Stack 470, Row 63, Box 189. NARA II,
[118] Bureau of Aeronautics Report, "Summary of Progress," 1 December 1941, pg. 19, RG72, Stack 470, Row 70, Boxes 1-3, NARA II.

was a combination of both aviation ratings and general ratings required to support flight operations around the globe as were the previous estimates of 1937. The following table represents the actual numbers of enlisted personnel serving in support of naval aviation activities just before the U.S. entered the war. The numbers reflect both Regular Navy personnel and Reserve personnel recalled for active duty.

Table 2-2: Aviation Enlisted Personnel on Active Duty [119]

Date	Enlisted Personnel in Aviation Service
1 July 1940	22,503
1 September 1941	48,267
1 October 1941	50,634
1 November 1941	56,402
1 December 1941	59,353

Considering the 15,000-plane program was not law until the middle of June 1940, Towers' estimate in 1937 was on target to what the navy should have to support a 3,000-plane force, keeping with the ten to one ratio that was suggested by Moffett a decade earlier. Even with an estimated requirement of one hundred and twenty thousand enlisted personnel, an undertaking of this magnitude in naval aviation was unprecedented in United States history. Would it be enough?

In mid-summer 1940, Rear Admiral Horne was tasked with providing an update to his personnel requirement recommendations of a year earlier. Once the Vinson-Walsh Act was signed into law on 19 July 1940, Horne's team went back to work. His second

[119] Ibid.

submission came on 25 November 1940, and his end goal for the total number of enlisted men in the naval air arm totaled 119,092. Furthermore, he recommended that 47,960 enlisted men should be serving in support of naval aviation by the end of fiscal year 1941.[120] However, of the approximately forty-eight thousand enlisted men that were supporting naval aviation on 1 September 1941, only eleven thousand were qualified aviation ratings.[121] Was that enough for a navy that would soon be at war?

The difference between skilled and unskilled labor of the navy's air arm continued to gain the attention of decision makers. During the interwar years, the peacetime navy did not focus on the amount of skilled labor versus unskilled labor that a war required. The Secretary of the Navy's Annual Report of 1945 provides a statistical record of the war, including the actual number of officers and enlisted on duty that was divided into six-month intervals.[122] Unfortunately, it is not further divided by rating other than flying and non-flying, but it does specify that its data represents only aviation personnel, rather than including those personnel supporting aviation activities. The numbers are significantly smaller in this report compared to the Horne Board estimates and the monthly status reports generated by BuAer for the War Department and Congress. For example, the BuAer monthly summary report lists 22,503 enlisted as the "Total Number in Service" on 1 July 1940, but the statistical record states that only 5,924 non-pilot enlisted were part of "Aviation Personnel."[123] The reason for the discrepancy comes down to specific ratings. Horne did not specify in his report how many of each

[120] This data is found in a memo dated 7 December 1940 from BuNav to BuAer. It reports and is part of enclosure (A) in the Confidential Supplement of the second Horne Board report of 1940. As cited in Bureau of Aeronautics, "Aviation Personnel and Training," 1959, 313.
[121] The specific number of aviation ratings is listed as 11,213 in *Annual Report of the Chief, BuAer for Fiscal Year 1941*, as cited in Bureau of Aeronautics, "Aviation Personnel and Training," 312–13.
[122] "Annual Report of the Secretary of Navy: Fiscal Year 1945," sec. Appendix A.
[123] "Annual Report of the Secretary of Navy: Fiscal Year 1945," A-21.

rating was required. If the navy met Horne's estimated numbers on paper, then it would have appeared as if everything was working as planned. In addition, Towers did not want to give up control of aviation matters. Towers had told George Murray in December 1940 that the personnel operations of the Bureau were sufficient to handle the increased requirements. But as the United States' entry into the war slowly became reality, the question of how BuAer would determine exactly how much skilled labor would be needed to effectively fight a major air war was still unanswered.

The CNO, Admiral Stark understood the requirements necessary to meet the 15,000-plane order. If the expansion program were to be successful, a trifecta consisting of thousands of planes, hundreds of pilots, and ten-thousands of ground personnel would have to come together at once. Recruitment alone would not solve the problem. Very few new recruits entered the navy previously qualified as aviation technicians. Stark understood that merely throwing more personnel at the problem would not equate to building an aviation navy strong enough to fight wars in both the Atlantic and the Pacific. "The future success of our active air operations at sea depends in no small measure on the thoroughness of the preliminary training given on shore." Stark went on to say that new aviation training schools needed to be established, and "every effort is being made to maintain a very high standard in our training institutions…" Stark's comments were published in the "U.S. Naval Aviation" issue of *Flying and Popular Aviation* that appeared on newsstands in January 1942. It can be inferred that these article contributions were written before Pearl Harbor, in the fall of 1941, based on the information and tone of the articles, as well as the advertisements in the magazine. No mention of being "at war" was found in any of the articles. Most advertisements

referenced the "preparation" for national defense, etc. Hence "the recruiting of large numbers of men for Naval aviation duty" might have seemed daunting before the emotional response and rush to the recruiting stations by the American public after December 7, 1941.[124] As Stark indicated, the key to success was not just bringing Americans to the recruiting centers, but the nature of their training and schooling after boot camp as well. For naval aviation, vocational training and technical education of its enlisted labor force mattered as much, if not more, than simply filling the ranks with bodies.

[124] Rear Admiral Ben Morelli, "The Naval Air Station," *Flying and Popular Aviation*, January 1942, 194. A careful analysis of the advertisements, articles, and statements by contributing authors such as Admirals Stark, Halsey, Towers and others give no indication that the U.S. was at war during the exact time of submissions. A hard copy of this periodical can be found at USNA Nimitz Library.

Chapter 3: Establishing the Trade Schools

Naval Aviation technical training prior to 1940 was a conglomeration of small independent maintenance schools that operated through an apprentice-style, on-the-job training. Trainees were given ample amounts of time to study on their own outside of classroom instruction. The navy was accepting of shortcomings in ship and squadron personnel due to non-standard syllabi and lengthened the "time to train" depending on an individual's talent, large or small.[125] Not until war was imminent, and FDR had authorized a build-up of naval aircraft, did BuAer and BuNav change gears to ensure a more structured and disciplined, and therefore effective, training system for aircraft technicians for the navy. Once the training of maintenance personnel became a priority, both the quality and quantity of training increased exponentially. What was considered an afterthought during the interwar years, soon became a critical need that required cutting-edge engineers and industry giants to partner with the navy to remedy the problem. It also demanded vast amounts of funding to establish a training program sufficient to produce the number of properly trained technicians necessary to support the Fleet's burgeoning aviation units. Solving the navy's aircraft technician training dilemma did not occur overnight, but by early 1943 the navy had figured out a way forward.

Throughout the 1930s, there had been little standardization of aviation maintenance curricula for student aircraft technicians. Most of the navy's enlisted

[125] LCDR A.W. Wheelock, "Lecture on Duties of Divisions in the Bureau of Aeronautics, Navy Department," January 1942, sec. Training Division, RG 72, Entry 172, Box 1, Stack 470, NARA II.

technicians learned their trade by apprenticing with a veteran mechanic. These young, untrained "strikers" as they were called, worked alongside veterans who had earned their ratings through hard work and hands-on experience. Usually the training occurred at local naval air stations or the nearest Assembly and Repair (A&R) facilities. Since World War I, BuAer had relied on a regular rotation of sailors in and out of the A&R facilities for most of the navy's aircraft technician training. In 1938, A&R facilities in San Diego, Norfolk and Philadelphia handled the majority of the fleet's overhauls, with a limited number of smaller facilities located elsewhere. The navy also relied on instruction from the Army Air Service schools to train many of their technicians simply because the Army already had the infrastructure in place. Another challenging factor was that the navy's technical training program more closely resembled that of commercial trade schools than formal training centers. The caliber of each school and its graduates depended more on the ingenuity and motivation of its officer-in-charge and veteran personnel, than on the curriculum or training material itself.[126]

Until the spring of 1940, only nine formal trade schools designed to teach aircraft maintenance were in existence.[127] The Naval Training Center (NTC) in Norfolk, Virginia housed one basic and one advanced trade school for Aviation Machinist's Mates (AMM), plus advanced schools for Aviation Ordnancemen (AO) and Aviation Metalsmiths (AM). Aviation Machinists' Mates and Metalsmiths also had schools in

[126] T.B. Haley, "Historical Report of the Technical Training Section through December 1943," December 1943, 2–3, WW II Training, Box 68, Technical Training Reports 1943, NHHC; Bureau of Aeronautics, "Aviation Personnel and Training," 1959, 310.

[127] The U.S. Army Air Force also had a had been supplementing the education of its own aircraft technicians with civilian schools at this time. They established the Army Technical Training Command in 1941, prior to Pearl Harbor. By November 1941, the AAF had plans to turn out trained aircraft technicians at a rate of 100,000 per year. Source: Wesley Frank Craven and James Lea Cate, eds., *The Army Air Forces in World War II*, vol. 1, Plans and Early Operations, January 1939 to August 1942 (Chicago, IL: The University of Chicago Press, 1955), 111.

Pensacola, Florida and San Diego, California. Additionally, there was a small school for aircraft instruments located at the Naval Aircraft Factory in Philadelphia.[128] The 1939 Horne Board estimated that by 1942, assuming a 3,000-plane navy, there should be 556 naval aircraft technicians under training in aviation maintenance schools at any given time.[129]

Everything changed when FDR authorized more aircraft with the expansion program, eventually settling on 15,000 in June 1940, five times the number authorized just two years earlier. The navy realized that the number of trained aircraft technicians currently serving, plus those undergoing training, was wholly insufficient to support an aviation fleet of such magnitude. The old system of utilizing A&R shops to complement the limited number of trade schools, could only provide 15 percent of stated technical labor requirements. BuAer recognized the shortcomings of the existing arrangements, and sought funding to establish an aviation technical training school in Jacksonville, Florida. Construction was projected to be completed in just six months, opening its doors to 3,000 new students in January 1941. Prospective Aviation Machinist's Mates, Aviation Metalsmiths, Aviation Radiomen, and Aviation Ordnancemen would learn their trades at NAS Jacksonville and report to the fleet as skilled technicians upon graduation.[130]

As far back as 1938, naval aviation had recognized there was a problem with the imbalance of logistical support capacity in relation to the projected force expansion. Based on findings from a board convened to study the U.S. defense capability and

[128] Haley, "Historical Report of the Technical Training Section through December 1943," 2.
[129] Horne, "Aviation Personnel Board 1940-1941."
[130] Haley, "Historical Report of the Technical Training Section through December 1943," 3–4.

infrastructure, chaired by Admiral Arthur J. Hepburn, the navy lacked shore establishments along the eastern seaboard that could carry out required maintenance and operational tasks. Hepburn's 1938 report was informally titled "A Guide for Expansion of Peacetime Shore Establishments." However, it was no secret that the increased threat of war was front and center in his thought process. Much emphasis was placed on establishing operational bases in the Pacific, but there was deliberate mention of Jacksonville being developed into and operational training facility for aircraft maintenance.[131] Within BuAer in 1940, the decision of how to manage the assignment of personnel for aviation duties including technical, or "vocational" training was first placed into the capable hands of a few experienced aviation officers, most notably Lieutenant Commander (LCDR) Austin W. Wheelock, USN.

LCDR Wheelock reported to BuAer on 7 May 1940 and was immediately assigned to the Personnel Division. A graduate of the U.S. Naval Academy in 1925, his previous assignments included duty flying patrol aircraft in with VP-4, stationed at Pearl Harbor, torpedo bombers with VT-1B from the USS *Lexington* (CV-2) and scouting sea planes in VS-5B from the light cruiser USS *Marblehead* (CL-12). He also served on various staff tours including Commander, Aircraft Battle Force.[132] Wheelock was an experienced pilot who understood the needs of fleet maintenance and the technical skills required of technicians to keep the navy's air force aloft.

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[131] B.W. Patch, "American Naval and Air Bases.," CQ Researcher, 1939, http://library.cqpress.com/cqresearcher/document.php?id=cqresrre1939021600; Ben Morelli, "The Naval Air Station," *Flying and Popular Aviation*, January 1942, 151; "Arthur Jepy Hepburn, Admiral United States Navy," Arlington Nation Cemetery, July 8, 2009, http://www.arlingtoncemetery.net/ajhepburn.htm. (accessed May 10, 2019)

[132] "Captain Austin Wadsworth Wheelock, U.S. Navy" (Bureau of Naval Personnel, January 18, 1945), Officer Biography Folder, NHHC.

The initial mission for Wheelock's section was to establish a training system for officer and enlisted airmen under the cognizance of BuNav. The thought process was since BuNav managed personnel entry and detailing throughout the fleet, Nimitz's staff should have cognizance over the training, while officers from BuAer served as key liaisons and advisors.[133] This plan was part of George Murray's 1939 suggested remedy which he proposed to Towers and Mitscher due to the sharp increase in new aviation personnel. As discussed in the last chapter, this plan did not survive for long.

With the build-up of naval air forces came the increase in size of the aviation training program. Shortly after Wheelock had settled into his billet within the Personnel Division, BuAer requested that the Commanding Officer of NAS Norfolk establish a school that could house 400 AMM students. They also requested a similar facility addition for NAS San Diego, but larger so that it could house 800 AMM students. It was assumed, as was the custom during the interwar years, that adequate instruction could be accomplished through the A&R shops located within the naval air stations. Problems arose however, when A&R shop personnel could not keep up with the demands of both training new technicians and simultaneously completing their routine overhaul work. Thus, the quality of the navy's new aviation labor force deteriorated.[134]

Steps were taken to provide the students with facilities and instructors that were separate from the A&R shops. Existing schools were expanded as much as possible and the number of trained graduates began to increase. By the end of 1940, BuAer was on pace to graduate approximately 9,000 technicians every four months. Rear Admiral Towers was quite comfortable with these numbers and the overall status of his training

[133] Haley, "Historical Report of the Technical Training Section through December 1943," 2.
[134] Haley, 3.

programs throughout the following spring. When testifying on the status of BuAer's training programs before Congress on 22 July 1941, he stated, "Subject to obtaining the requisite number of planes for advanced [pilot] training, I can report the navy's aviation training program is shipshape and under way ahead of schedule for both pilots, flight crews and maintenance personnel."[135] Towers' response to Congress was either inflated, ignorant, or simply erroneous. The fixes that had been put in place over the previous fifteen months since Wheelock had reported to BuAer were only improvised expedients for a systemic problem facing BuAer and BuNav.[136]

In September 1941, the Assistant Secretary of the Navy for Air, Artemus Gates appointed a board to analyze the current efforts to train both officer and enlisted personnel in pilot and technical matters. It was chaired by Commander G. F. Bogan. Based on interviews and historical data, the Bogan Board determined that the size of the aviation training program had grown so large, that aviation officers concluded that the program would be better placed under BuAer cognizance. The request was thus submitted up the chain of command with the following explanation:

> The scope of aviation training, both ground and flight, has become so great that its operations under existing conditions is slow, cumbersome, and difficult in administrative control. It is strongly recommended that responsibility for this training be made that of the Chief of the Bureau of Aeronautics, and that the administration thereof be under the Bureau. In this connection, the formation of a training division within the bureau, solely for training, has been considered.

[135] House Hearings, Sundry Naval Legislation, 77th Congress, 1st Session, 1941, 2056. As quoted in Bureau of Aeronautics, "Aviation Personnel and Training," 1959, 195–96.
[136] Haley, "Historical Report of the Technical Training Section through December 1943," 4.

> Consideration has also been given to the assignment of an officer of suitable rank, who, together with his staff, should function as Director of Training.[137]

Towers recognized that here was an opportunity to break free from oversight by Nimitz and BuNav. He strongly supported the Bogan Board's recommendation that the control of all facets of aviation training be placed under BuAer's purview. On 3 October 1941 Towers responded to the Bogan Report. In his memo to the Secretary of the Navy he said, "Our present training effort can be speeded *(sic)* up appreciatively through administrative action within the Department."[138] Towers understood the original 1920 navy charter which placed responsibility of all personnel training programs under the cognizance of BuNav. However, he was aware of the "duplication of effort" and the resultant time lag in accomplishing associated tasks and did not support the status quo. He recommended that BuAer be responsible for planning and executing all aspects of aviation training, to include pilots and technicians.[139]

Towers backed his opinion with the following facts: BuAer already had a framework to administer all stages of training; the majority of training schools were geographically located on naval air stations that depended on BuAer for material support; the training of aeronautical personnel was specialized and could only be administered by aeronautically-trained personnel. This last proposal was comparable to the Bureau of Medicine's training program, which for similar reasons operated independently of BuNav. The shift in supervisory authority would promote, faster and better-informed

[137]Bogan Board Report, 19 September 1941, as referenced in Bureau of Aeronautics, "Aviation Personnel and Training," 1959, 274.
[138] Bureau of Aeronautics, "Aviation Personnel and Training," 275.
[139] Ibid.

corrective measures to training programs than would be the case if BuAer only operated in an advisory role.[140]

Naturally, Nimitz objected to completely handing over the administration of aviation personnel and training to Towers. His objections were based on precedent and the current status of aviation training. He countered Towers' reasons by claiming that excellent cooperation had always existed between BuNav and BuAer and that there was no duplication of effort. Only a small staff of BuNav officers was present to administer the program in accordance with BuAer wishes and coordinate incompatible direction from the Office of the CNO. Nimitz did not interpret the Bogan Report to say that BuNav should completely give up its functions with respect to aviation. He concluded his argument by suggesting that separating control of aviation personnel from the Department of the Navy's personnel Bureau was contrary to the principles of the bureaucracy's design. Instead, Nimitz recommended that offices and staff of BuAer's Training Section and the Training Division of BuNav be located together so that they might function more as a single unit and increase the pace at which they achieved their goals. Nimitz's response was forwarded to the Secretary of Navy on 13 October 1941, just ten days after Towers had made his wishes public.[141]

Approximately two weeks later, navy leadership met with hopes of reaching an agreement to send up to the Secretary of the Navy for approval. Admiral Stark and the Assistant Secretary of the Navy for Air, Artemus Gates, both sided with Nimitz. Everyone except for Towers was against the change. They agreed upon co-locating personnel for each Bureau and suggested a new billet be established to oversee the entire

[140] Bureau of Aeronautics, "Aviation Personnel and Training," 1959, 276–77.
[141] Ibid., *277.*

process. Admiral Stark suggested that the new billet be one of a senior ranking officer and have equal allegiance to the Offices of CNO, BuAer, and BuNav. His primary job would be to administer the training program. The senior officer would assume the title "Director of Aviation Training." In addition to reporting to Towers at BuAer, he would also report to Nimitz at BuNav, as well as the CNO, on all matters of aviation training. His primary duty would be Director of Aviation Training at BuAer, with additional duties named as Assistant for Aviation Training in both the Office of Chief of Naval Operations, and the Bureau of Navigation. The measure was formally approved by the Secretary of the Navy on 21 November 1941. Captain Arthur W. Radford was appointed the first Director of the Aviation Training Division.[142]

Radford quickly implemented changes within the administration of BuAer's training program. One of the first changes he made was to place LCDR Wheelock in charge of all technical training. This put the onus of managing both officer and enlisted training on Wheelock's shoulders. He was in charge of all basic aviation rating training taking place in the existing trade schools, in specialized and advanced enlisted training centers, and in radar training schools. He was responsible for officer and pilot ground school training as well. However, radar and ground school training for pilots were soon separated from the Technical Training Section and given their own sections under the Aviation Training Division.[143] In narrowing the focus of Wheelock's section on training the technicians, the expansion of the navy's aviation labor force began to show progress. However, the navy's trade schools were geographically dispersed throughout the country

[142] Ibid., 276–77; Haley, "Historical Report of the Technical Training Section through December 1943," 2.
[143] Haley, "Historical Report of the Technical Training Section through December 1943," 2.

and operated with little BuAer oversight. Unsupervised and non-standardized training would prove to be insufficient to meet the demands of the Fleet.[144]

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A year earlier, it had been decided that Naval Air Station Jacksonville, Florida would be the site for the navy's newest school for aviation technical training. Initial planning for the massive trade school had begun during the summer of 1940 and the school's door were forecast to open in January 1941. Unfortunately, the navy still needed to train technicians, so San Diego, Pensacola, and Norfolk had to increase their output of graduates three-fold. For example, NAS San Diego had a regular capacity of 500 Aviation Machinist's Mates at one time, but under duress 1,500 graduates passed through its doors in 1940. NAS Pensacola normally accommodated 160 Aviation Machinist's Mates and 280 Aviation Metalsmiths at one time. But by 2 January 1941, 480 AMM's and 840 AM's had completed the curriculum and joined the Fleet. NAS Norfolk saw a similar push for new Aviation Machinist's Mate graduates and tripled its output from 400 to 1,200 trained sailors. By January 1941, the Training Section under Wheelock had overhauled the existing schools and curricula to graduate 5,520 aviation technicians (Aviation Radiomen, Aviation Machinist Mates, Aviation Metalsmiths, and Aviation Ordnancemen) in just six months, when the normal capacity was 1840.[145] Yet again, it was only a temporary fix for a more serious problem.

NAS Jacksonville was officially commissioned as a base for what the navy first called "Trade Schools" on October 15, 1940. Recently retired Commander Junius L. Cotton was ordered back to active-duty on 10 August 1940 in order to serve as the Trade

[144] Bureau of Aeronautics, "Aviation Personnel and Training," 1959, 333–35.
[145] Haley, "Historical Report of the Technical Training Section through December 1943," 4.

Schools first Officer-in-Charge (OinC). The first trade school classes at NAS Jacksonville did not convene until 2 March 1941. The trade school facilities were built to house 3,000 students at a time, consisting of Aviation Metalsmith, Aviation Machinist's Mate, Aviation Ordnanceman, and Aviation Radioman (ARM) ratings. Courses were designed to take an average of four months from start to finish. The BuAer Training Section estimated 43,000 enlisted aviation technicians would complete their respective training courses between 1941-1944.[146] The first cohort of classes for prospective Aviation Metalsmiths and Aviation Machinist's Mates began in March 1941. The following month Aviation Radiomen and Aviation Ordnancemen candidates began their respective courses.

The aviation schools in Jacksonville were initially designated as "A" schools. This denoted that they were structured to "give basic training designed to equip men to carry out the duties of a third class petty officer. Sailors were sent to "A" schools immediately following basic training or "boot camp." It was the first step in qualifying in "rate" rather than remaining an "undesignated" seaman. In order to advance in rank, new sailors had to "make rate." The schools covered a broad range of various phases of technical aviation. The navy also had "B" schools which were designed to deliver more advanced training suitable for more senior petty officer ratings. There were also "C" schools for specialized skillsets, but they did not fulfil full requirements for advancement in rate.[147]

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[146] "History of Naval Air Technical Training Center Jacksonville, Florida," October 31, 1944, 3,8, Aviation Commands, NATTC History 1940-1944, AR/180, Box 230, NHHC; Haley, "Historical Report of the Technical Training Section through December 1943," 4–5.

[147] "What Is the Naval Air Technical Training Command," *Bulletin of Naval Air Technical Training Courses*, 1945, 1, WW II Training, Box 68, NHHC.

Cotton made his initial inspection of the school's facilities as it was undergoing construction immediately after his recall to active duty. Before he arrived in Jacksonville, he studied the trade schools in Norfolk in order to understand how they operated and what materials were required. Cotton used this information to determine whether or not what was being built and the material provided by BuAer was sufficient to handle such a massive student load. To his credit, he did not think it was satisfactory. He reported his findings to the Prospective Commanding Officer of NAS Jacksonville, Captain Charles P. Mason, specifically noting, "…the list of material the Bureau of Aeronautics had prepared for the Metalsmith and Machinists Mate Schools was entirely inadequate in many items."[148]

Cotton elaborated on the details of his initial assessment in Norfolk which he believed needed to be considered during construction and curriculum development in Jacksonville. Problems like proper ventilation in the auditorium or how much to slope the deck in the auditorium so all students could have an unobstructed view of their instructor and media were first on his list of grievances. Other issues were identified, including where to place the movie curtain so it would not be damaged when converting the theater to a dance hall, and where to locate the scullery within the cafeteria system. As trivial as they might have appeared, they were valid concerns regarding the welfare of students in Cotton's mind.[149]

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[148] Junius Cotten, "Letter from J. Cotten to C.P. Mason," August 19, 1940, 1, Aviation Commands, AR/180, Box 230, NHHC.; "Prospective" is a term used for an individual who has been selected for a billet, but has not taken the oath of office or executed his or her official orders into such. It is commonly used with Commanding Officer or Executive Officer billets, and abbreviated PCO or PXO. Charles P. Mason retired as a Vice Admiral in 1946.

[149] Ibid.

His report also outlined his personnel requirements for the administration of the school. He asked BuAer for a total of 290 men, including officers, to meet the staff and faculty requirements. Cotton was concerned about the availability of officers assigned to the school because of competing requirements. He admitted to Mason that, "Officers are as scarce as hens' teeth," when asking for an experienced officer to run each of the four trade schools on base.[150]

The initial plans for the trade schools called for an instructor cadre of fifteen officers and 190 petty officers. The expectation was to house 1,850 students in the Aviation Machinist's Mates School, 400 in the Aviation Metalsmith School, 200 in the Aviation Ordnance School, and 150 in the Aviation Radioman School. According to a local newspaper article published on the commissioning day for NAS Jacksonville, opening an official Trade School was a first for the navy and for the country. Its graduates would only be assigned to units that were part of Naval Aviation, something the navy had not done before. The article concluded, "In this respect, the Trade School at Jacksonville is unique, for there is no other school in the country where so many specialties will be taught and where the men are being trained exclusively for aviation duty."[151]

Even before classes began, there were concerns about the quality of instruction in the schools. Initial staffing and maintaining a cadre of experienced instructors was paramount for the Trade Schools' success. The first instructors were rated petty officers selected from operational and existing training units. They were technicians by trade, but

[150] Ibid., 2-3.
[151] *Florida Times Union*, October 15, 1940, 6. As referenced in "History of Naval Air Technical Training Center Jacksonville, Florida," 9–10.

not trained in educational theory and practice. They were skilled aircraft technicians, but not necessarily skilled educators. As was the case across the Fleet, veteran aviation technicians in 1940-41 had been taught under the old system of "on the job" training. The schools they had attended were of a broad, general nature pieced together over the interwar years. The new aviation navy in this period of expansion was designed to operate specialized aircraft systems and required technicians who were specifically trained on such systems. A basic understanding of aeronautics, physics, and engineering theory was necessary for technicians to maintain modern aircraft engines, aerodynamic structures, and communications systems. The newly appointed instructors were weak in their ability to transmit such knowledge as their teaching experience to this point had been of a practical nature.[152]

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During the previous two years, the aircraft manufacturing industry had adopted the practice of mass production lines and embraced sophisticated technology. Grumman, Martin, Pratt & Whitney, and other aviation companies were beginning to resemble the auto industry of the 1920s. Recognizing there was a lack of knowledge of these new systems en route to the Fleet, some manufacturers supplied training equipment and factory technicians to the trade schools directly to assist the new instructors. Additional opportunities for training were provided by the manufacturers at the factories themselves for select petty officer instructors and maintenance officers. These augmentations were not unique to Jacksonville, but were in practice at other navy trade schools across the country.[153]

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[152] "History of Naval Air Technical Training Center Jacksonville, Florida," 22–23.
[153] "History of Naval Air Technical Training Center Jacksonville, Florida," 23.

The need for technical instructors was no small issue for the navy or the government. The United States Office of Education was enlisted to supplement teaching staff at military training schools. Together with the National Defense Training Program and the Florida State Department of Education, BuAer recruited experienced tradesmen from civilian jobs to work as civilian instructors at the Jacksonville Trade School and eventually others. It was a good idea in theory, although these individuals faced the same problems as the active duty navy instructors—most of their experience was that of a practical nature, not relevant to classroom instruction. Additionally, few of the civilian instructors had any experience with naval aircraft and weapons.[154]

In 1941, a civilian teacher program had been set up through a joint Army-Navy program operating out of Chanute Field in Rantoul, Illinois. It was based on BuAer's design for technical training at NAS Jacksonville. At this site a joint board sifted through numerous applications for technical aviation instructors at the navy trade schools and U.S. Army Air Corps technical schools. While successful at first, grumblings began when the pay gap between civilian teachers and military instructors widened. Civilians were paid a higher salary than the enlisted instructors for the same duties. Also, many of the civilians hired ended up being less effective at teaching than expected. Although the program fulfilled a critical gap in training at first, as time went on, the reality that civilian and military roles were not interchangeable became apparent. Still, the civilian teaching corps carried a greater share of classroom instruction until the program was ultimately ended in June 1942.[155] While many individuals left the school houses after this, some

[154] Haley, "Historical Report of the Technical Training Section through December 1943," 24.
[155] Buchanan, *The Navy's Air War*, 318.

stayed on and enlisted in the navy to continue their work. Others transferred to Civil Service, keeping their roles as aviation maintenance technician instructors.[156]

Another source of instructors was found among the ranks of newly graduated trade school students. These men had a working knowledge of the course material, but lacked the operational experience with much of the equipment. They were also handicapped by having little expertise in the area of theory.[157] As had been the case in other trade schools during the previous year, getting BuNav to approve retaining freshly trained technicians in the schools instead of detailing them to the Fleet was almost impossible.[158] BuAer's Training Section had a serious dilemma on their hands, and Nimitz's staff did not help matters

Another obvious concern was the availability and quality of training equipment for the technicians. Due to the unrelenting requirements of the Fleet, there was a limited supply of operationally representative aircraft and aircraft parts for students' instruction. What material they did have was usually obsolete, or salvaged from crashes and mishaps. In one particular case, a chief petty officer reported travelling to Norfolk to inspect a crashed PBY aircraft for the possibility of salvaging parts. He found nothing valuable from the damaged airplane, but instead located two other working, albeit very worn-out, models which he arranged to be transferred to Jacksonville where they served as teaching aids. The process to procure up-to-date aircraft systems for technical training purposes was without formal direction until 1943. The wartime Fleet was the priority for aircraft and aircraft parts. Until a surplus was reached, the trade schools had to "beg, borrow and

[156] "History of Naval Air Technical Training Center Jacksonville, Florida," 24.
[157] "History of Naval Air Technical Training Center Jacksonville, Florida," 25.
[158] Memo from BuAer to BuNav regarding AM post-graduate instructors, 23 August 1940, op. cit.

steal" what they needed. When the Jacksonville Trade School established its own Material Department on 17 December 1942, the procurement process for teaching aids was formalized and became more successful than its earlier version had been.[159]

Curriculum development was also a concern during the initial planning stages of the Trades School. In March 1941, LCDR Daniel J. Brimm Jr., USNR, was called to active duty for the sole purpose of developing instructional materials for the various BuAer technical trade schools.[160] He was an aviation engineer with a vast amount of experience in civil aviation during the interwar years. Brimm was well versed in aviation maintenance as well as flying. He was a former test pilot, but had made his mark in the aviation technical world. He was a licensed airplane-engine mechanic and an airplane engine instructor at the New York City School of Aviation Trades. Additionally, Brimm had been the manager at Marine Flying Service and Chief Engineer at the Ireland Aircraft Company. Most relative to his assignment within BuAer, he was a published technical author with three authoritative works on aviation to his name: *Airplane and Engine Maintenance for the Airplane Mechanic* (1936), *Seaplanes Maneuvering, Maintaining, Operating* (1937), and *Aircraft Engine Maintenance* (1939).[161] His experience and knowledge in the field made him an excellent candidate to supervise curriculum development desperately needed in BuAer's technical training.

In the fall of 1941, Brimm was sent to Jacksonville to observe the progress of the Trade School and comment on curriculum implementation. What he observed was not

[159] "History of Naval Air Technical Training Center Jacksonville, Florida," 26.
[160] Bureau of Aeronautics, "Aviation Personnel and Training," 1959, 318–19.
[161] Daniel J. Brimm and Harry Edward Boggess, *Airplane and Engine Maintenance for the Airplane Mechanic* (New York: Pitman Pub. Corp., 1936); Daniel J. Brimm, *Seaplanes Maneuvering, Maintaining, Operating.* (New York: Pitman Pub. Corp., 1937); Daniel J. Brimm and Harry Edward Boggess, *Aircraft Engine Maintenance* (New York: Pitman Pub. Corp., 1939).

impressive. His first observation was that the schools were short on instructional material and instructors. In one instance, Brimm observed only one aircraft available for hands-on training for nearly 1,000 students. He reported that classes of 200 students at a time would spend hours sitting in a hangar with nothing to do because of the shortage of technical models to work on. Often students spent their class time playing cards or other games.[162] Brimm's observations were described in a powerful memorandum that his coworker, Wheelock, sent to Radford on 1 December 1941. In this paper, Wheelock mentioned many problems in the trade schools. These were shortcomings in quality and number of instructors, lack of technical training equipment, problems with standardization across sites, updating instruction to most current methods, efforts to consolidate trade schools, factory training, and officer training.[163]

Brimm's observations were corroborated by the Columbia University's Dean of Engineering, Joseph W. Barker, who was also serving as Special Assistant to the Assistant Secretary of the Navy for Air. Barker's formal title was Chief of the Division of Training Liaison Coordination for the Secretary of the Navy. Barker toured other trade school and A&R facilities in Jacksonville and Pensacola from 8-16 May 1941. His observations confirmed Brimm's, repeating the earlier charges that there was little standardization in instruction and methodology across geographically separate training centers. By early summer 1941, Brimm and others in the Training Section were working feverishly to remedy the inadequacies of the existing program before it began to damage

[162] Bureau of Aeronautics, "Aviation Personnel and Training," 1959, 319.
[163] Memorandum of observations from Wheelock to Radford, December 1, 1941, also known as the "Wheelock Memo." Referenced in Bureau of Aeronautics, "Aviation Personnel and Training," 1959, 326–46.

the Fleet's combat effectiveness.[164] A generation of poorly trained naval aircraft technicians would undoubtedly have long-lasting ill effects on the navy's ability to fight an air war. It was up to Brimm and Wheelock to prevent such a disaster.

Finding qualified sailors to attend the trades schools was a serious challenge. Recruits had to show a general aptitude in their intended fields of future study, have an interest or previous experience in the field, and had to have "high degrees of petty officer potentiality" according to historical accounts. The minimum required scores in the General Classification Test (GCT) varied depending on rate.[165] For Aviation Machinist's Mates it was sixty-two and for the Aviation Ordnanceman community, it was a seventy. Little mention is made in official documents regarding different score requirements between ratings. However, one can infer that the navy wanted to ensure those technicians whose jobs required the most unforgiving tasks, such as weapons handling, were some of the brightest in the hangar. BuAer also recognized that the intellectual requirements of an aviation technician were greater than what general service ratings needed. Thus, they set limits on what scores were acceptable and what scores would get you reassigned to general shipboard rating schools. Taking it one step further, the ordnance community required a personal interview with interested recruits that focused on their interest in the

[164] Bureau of Aeronautics, "Aviation Personnel and Training," 319.

[165] The General Classification Test was a general aptitude test that the Army developed in WWI. The Navy adapted it for its own purposes to determine the general aptitude of applicants. The test was revised during the war and minimum score requirements varied. The scores "62" and "70" were based on a previous edition of the test. By 1943, the minimum test scores had been reduced to "52" for these two ratings. It is unclear whether this was due to test revision or a lowering of the minimum standard for trade school applicants. According to the Navy's instruction for GCT interviews, "The object has been to set the minimum scores at a level which would insure the inclusion of a sufficient number of men to meet the needs of the fleet, and, at the same time, to select those men most likely to meet the school requirements successfully." See "US Navy Interviewer's Classification Guide, NAVPERS 16701," 1943, NHHC, https://www.history.navy.mil/research/library/online-reading-room/title-list-alphabetically/u/us-navy-interviewers-classification-guide.html#mm, accessed 4 October 2018.

ordnance program.[166] BuAer did not want to give up the investment it was making in each one of these sailors once a sailor graduated from a Trade School. Therefore, graduates were assigned an aviation rating commensurate with their field of study, which ensured they would only be assigned to aviation activities for the remainder of the war.[167]

The Jacksonville Trades School was instrumental in developing a model for recruitment and rating selection. In a 1943 version of the "US Navy Interviewer's Classification Guide" the Bureau of Personnel (formally BuNav) stated that the minimum GCT score for AO and AMM was a fifty-two for both ratings.[168] The GCT was revised by the navy around the same time, but it is debatable if the lower score reflected intricacies of an updated test, or more likely, a lowering of standards in order to meet the labor demand of the aviation navy.

Nevertheless, the complexity of modern aircraft and their weapons system required a higher degree of aptitude in its technicians. A comparison of other minimum GCT scores for non-aviation ratings such as Machinist's Mates (MM) or Gunner's Mate (GM) shows a fifty and forty-five, respectively. This does not imply that aircraft technicians were the brightest of all the navy's ratings, however. The Radio Technician (RT) rating had a minimum of sixty and Quartermaster (QM) was fifty-five. Another difference in classification standards was in what the navy listed as part of the "Personal" qualifications for selection to aviation rates. AMM and AO both listed "calmness under stress" as a qualifier. MM and GM had no such requirement. In all fairness however, there were some non-aviation ratings that had comparable if not more stringent criteria.

[166] "History of Naval Air Technical Training Center Jacksonville, Florida," 275, 400.
[167] "History of Naval Air Technical Training Center Jacksonville, Florida," 29.
[168] "US Navy Interviewer's Classification Guide, NAVPERS 16701." Accessed 4 October 2018.

The minimum GCT score for Fire Controlman (FC) was sixty and also made "calmness under stress" a prerequisite.[169] Candidates for aviation ratings were not necessarily the most scholastically astute of the all enlisted men and women, but they were among the top of the available labor pool.

The capacity of Jacksonville to deliver technicians to the Fleet fluctuated both before and during the war. After the attack on Pearl Harbor, the demand for graduates increased greatly over the next few years, reaching its peak during the summer of 1943. At times, Allied technicians from Great Britain, France, Brazil, Cuba, and even three students from Uruguay were trained at Jacksonville. The following table breaks down the numbers of enlisted navy and Marine Corps students per month from March 1941 through December 1943.

Table 3-1: Summary of Enlisted Personnel by Month[170]

Date	Navy Students	Marine Corps
31 Mar 41	1424	189
30 April 41	2097	264
30 Jun 41	2727	301
31 Jul 41	2495	320
31 Aug 41	2683	350
30 Sep 41	2647	267
31 Oct 41	2577	451
30 Nov 41	2576	447

[169] Ibid.
[170] "History of Naval Air Technical Training Center Jacksonville, Florida," 45–47.

31 Dec 41	2591	489
31 Jan 42	2991	336
28 Feb 42	2741	285
31 Mar 42	2898	1260
1 May 42	3271	2099
1 June 42	3164	2416
1 Jul 42	3286	3107
1 Aug 42	4439	3548
1 Sep 42	4324	3429
1 Oct 42	4705	3632
1 Nov 42	5298	4037
1 Dec 42	5501	3577
1 Jan 43	5582	3363
1 Feb 43	5633	3691
1 Mar 43	5663	3691
1 Apr 43	5687	3538
1 May 43	5434	3848
1 Jun 43	5275	4161
1 Jul 43	5089	3942
1 Aug 43	4835	3838
1 Sep 43	4406	3838
1 Oct 43	4215	3063
1 Nov 43	3975	2771

1 Dec 43	3207	2541

The rapid influx of students by the mid-1942 through mid-1943 coincides with aircraft manufacturers' increased production. Grumman signed a contract with the navy to build and deliver 675 F4F (-3 and -4 models) *Wildcat* carrier fighter aircraft beginning in August 1942 and continuing through March 1943. Earlier contracts on the F4F assured a delivery of 819 airplanes between December 1940 and March 1943.[171] Wheelock and his staff must have foreseen the tidal wave of technician requirements that was on the horizon and therefore, responded with the uptick in technical students under training that coincided with the manufacturing output of navy fighters.

The high number of students also parallels the shipbuilding industry's production of aircraft carriers. Looking at the contract data for the *Essex*-class aircraft carriers, the first keel was laid down on April 28, 1941. Construction on two more began that same December. Four *Essex* class aircraft carriers were commissioned before January 1944: *Essex* (CV-9), *Yorktown* (CV-10), *Intrepid* (CV-11), and *Hornet* (CV-12). In 1943 designs were adjusted for an increase in aircraft complement from the original eighty-two aircraft per ship to ninety. By August 1944, the number had been raised to ninety-six, and to 103 in June 1945.[172] The original *Hornet* (CV-8) maintained a complement of seventy-two aircraft and 601 enlisted personnel assigned to aviation department. It is worth noting that the number of personnel decreased with the new *Essex* class. CV-9 only made space for 537 enlisted aviation ratings in the original plans drawn up in

[171] Bureau of Aeronautics, "Analysis of Naval Airframe Production Contracts," August 11, 1945, NAVAIR Collection, Box 69, NHHC.
[172] Norman Friedman, *USS Yorktown (CV-10)*, Ship's Data 7 (Annapolis, MD: Leeward Publications Inc., 1977), 20,50.

1940.[173] There is no obvious explanation for this. One can only infer that perhaps there was an expectation that the newer airframes and ships would require less maintenance. The other possibility could be that the navy realized there was an insufficient number of trained aviation personnel to fully outfit all of the aircraft carriers that would be required to deploy a portion of FDR's 15,000-plane program. Nearly 100 smaller, unplanned "light" or "escort" carriers were built during the War. The navy had to maintain its armada of aircraft and supply the labor needs on the smaller carriers. Perhaps the decreased numbers per ship was a strategic decision to spread their technicians sparingly to make up the difference. Nevertheless, the demand on the Trade School command was high. After analyzing the capacities of the navy's operating Trade Schools, Brimm sent a memo to BuAer Director of Training, Captain Radford, on 29 November 1941 that illustrated the actual and desired output. Brimm's recommendations are depicted in Table 3-2.

Table 3-2: Trade Schools Current and Planned Capacity, as of 29 November 1941[174]

School	Capacity-November 1941	Planned/Future Capacity
NAS Jacksonville	AMM-2080 AM-400 ARM-300 AO-200 Total-2980	4372
NAS Pensacola	AMM-176	456

[173] A. H. Van Keuren, "Letter from BUSHIP to SECNAV, 'Design of U.S.S. Essex Class,'" September 10, 1940, Carriers Collection, Box 7, NHHC.
[174] Memo from LCDR Brimm to CAPT Radford, November 29, 1941 as referenced in Bureau of Aeronautics, "Aviation Personnel and Training," 1959, 322.

	AM-280 Total-456	
NAS San Diego	AMM-500 ARM-360 AO-200 Total-2060	1060
NAS Alameda	AMM-448 AM-152 ARM-200 Total-800	1600
NAS Seattle	AMM-448 AM-152 ARM-200 Total-800	1400
Navy Pier Chicago	AMM-700 AM-300	6000
NAS Norfolk	AMM-600 Total-600	600
NTS Norfolk	AMM-75 AM-25 AO-24 Total-124	124
Detroit (Dearborn)	AMM-628 AM-272 Total-900	0-Students transferred to Chicago when Navy Pier school became fully operational

The greatest increases in student matriculations were planned at Navy Pier Chicago and NAS Jacksonville. These two locations would become the backbone of aviation technical training for the navy in the first year of the war. Even with the planned

increase, the navy was still short on technicians due to its inadequate aviation training program during the interwar period. The navy needed trained technicians and was funneling fresh boot camp graduates to Jacksonville as quickly as they could, but there were only so many available seats in each classroom. It would take a creative mind willing to embrace institutional change for there to be any measurable impact.

In December 1941, the new Officer-in-Charge of NAS Jacksonville Trade Schools, LCDR Ronald D. Higgins, proposed a plan to modify the daily operations of the schools in order to graduate more students without having to utilize a commensurately larger number of instructors. This was in response to the recent expansion to accommodate nearly 4,500 students at one time since the Marine Corps had made a request to begin sending its own student aircraft technicians to the schools for training.[175] Higgins' plan involved staggering classes, so two groups of students instead of one could cover the same amount of material each day, expanding the output of the trade schools.

On 2 March 1942, the NAS Jacksonville Service Schools transitioned from one shift per day to two.[176] This was the only way the school could manage to keep up with the incoming waves of students. The early shift began their day at 0430, with breakfast at 0450. First period classes began 0550 and ended at 0650. Second period went until 0750, third until 0850, and every hour so forth until the academic day officially ended at 1850. Lunch and supper were squeezed in at 1005 and 1530, respectively. Official lights out, or taps, was at 2030 each day. The late shift was held to an identical schedule,

[175] Bureau of Aeronautics, 320. In early 1942, the "Trade School" name was dropped in favor of "Service Schools.

[176] In 1942, the Navy changed the official name from "Trade Schools" to "Service Schools."; "History of Naval Air Technical Training Center Jacksonville, Florida," 398.

except their day began at 0630 with reveille and taps was at 2230.[177] The two-shift policy was successful and soon became the norm within other naval aviation technical schools. The schools also transitioned from a five-day work week to a six-day work week in September 1942 which significantly cut down the training time in all rates. At the Aviation Machinist's Mate School, training time was reduced from twenty-six weeks to twenty-one as a result of the six-day week.[178]

The Aviation Machinist's Mate School at Jacksonville was the largest of all four schools. Its enrollment routinely represented one-half to two-thirds of all students on the base. When the school first opened in 1941, sailors were graduated without a rating. BuNav quickly recognized the problem with this because new graduates were leaving the school and then being reassigned to jobs that did not apply anything they had learned over their sixteen-week course of instruction. BuNav made a change in late 1941 that stipulated 25% of each graduating class would be rated as AMM. By June 1942 the bar was lowered to rate "all who were satisfactory," presumably to get rated aviation technicians to the Fleet. In May 1943 the number was restricted to 50%, and finally in November 1943, returned to 25%. By this time, the navy had reached an excess of petty officers in the fleet, and it was desired that only those who possessed the most technical acumen and leadership should start their first operational tour as a petty officer. Students who did not graduate with grades satisfactory enough to warrant their immediate

[177] Service Schools Memorandums 5-42 and 48-42, February 27, 1942 as referenced in "History of Naval Air Technical Training Center Jacksonville, Florida," 56–58.
[178] "History of Naval Air Technical Training Center Jacksonville, Florida," 405.

promotion to Petty Officer 3/C were given ample opportunities to do so once the reported to their next assignment.[179]

The 21-week course of instruction for an aspiring aviation machinist's mate was broken down into four phases. The Basic phase lasted two weeks and included blueprint reading, mathematics, basic ordnance and hand tools. The Airplane phase took seven weeks and covered the following topics: fabric, instruments, hydraulics and landing gear, controls, structures, and emergency equipment. The eight-week Engine phase was the longest. It taught overhaul, lubrication, accessories, ignition, propellers, and troubleshooting. The last four weeks of school was the Operational phase which covered aircraft recognition and squadron operations.[180] The training did not always employ the most experienced instructors, nor did it have the most up-to-date models for hands-on learning, but after Brimm made his changes to the curricula, it was certainly thorough. Upon graduation, most technicians were sent to the carrier navy, but some made their way to shore-based commands such as patrol squadrons, A&R facilities, or Carrier Aircraft Service Units (CASU).[181]

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In addition to the problems of standardization, instructor availability, and training, it did not take long for BuAer to realize NAS Jacksonville's facilities would fall short, mostly because of the high numbers of students required to meet the needs of the Fleet. The navy needed to expand beyond NAS Jacksonville for the majority of its aviation technical training. Fortunately, there were a number of smaller technical training

[179] "History of Naval Air Technical Training Center Jacksonville, Florida," 400–401; Bureau of Naval Personnel, "History of Enlisted Personnel Activity," 50.
[180] "History of Naval Air Technical Training Center Jacksonville, Florida," 407.
[181] An in-depth discussion of the CASU is included in chapter 5.

facilities already in existence before the war began. During the summer of 1941, another school for Aviation Machinists' Mates was established in Chicago, Illinois. The Chicago Vocational School, located at 87th Street and Anthony Avenue, Chicago was initially a civilian technical school, but partnered with the navy to provide much needed technical training to AMM rates that could not be billeted in Jacksonville. While the training itself might have been sufficient, the logistics of getting students from their barracks to the classroom every day was not. Housing for the navy students was situated at the Naval Armory. The Armory was located 87 blocks away from the vocational school and it housed other sailors attending various other schools throughout the city. The situation was less than ideal and the navy had to make a change.[182]

In the fall of 1941, Commandant of the of the Ninth Naval District, Rear Admiral Henry V. Butler, recommended a service school be built at Navy Pier in downtown Chicago. Butler was responsible for all naval activities in the greater Chicago area.[183] His plans included housing and classroom facilities for 6,000 students, initially for Aviation Machinists' Mates and Aviation Metalsmiths.[184] BuAer and the navy agreed with his proposal and acquired Navy Pier from the City of Chicago. Classes began almost immediately in December 1941, relieving some of the pressure on Jacksonville.[185]

Chicago was not the only city with a naval technical school that was struggling to keep up with the student demand. Norfolk, Pensacola, and San Diego were all expanded to handle more students. Additional technical training schools were also set up in

[182] Haley, "Historical Report of the Technical Training Section through December 1943," 5; Bureau of Aeronautics, "Aviation Personnel and Training," 1959, 320.
[183] "Ninth Naval District," Naval History and Heritage Command, accessed May 10, 2019, https://www.history.navy.mil/research/library/research-guides/lists-of-senior-officers-and-civilian-officials-of-the-us-navy/district-commanders/ninth-naval-district.html.
[184] See Table 3-2.
[185] Haley, "Historical Report of the Technical Training Section through December 1943," 5.

Alameda, California; Seattle, Washington; Dearborn, Michigan; and Great Lakes Naval Station in north of Chicago. The Naval Training School (NTS) in Dearborn was hosted by Henry Ford on the grounds of the Ford Motor Plant. Barracks and messing quarters were built next to the River Rouge Plant in Dearborn. Ford entered into agreement with the navy to provide instructors and a specialized curriculum for aviation machinists' mates on aircraft engines. The Ford Company was subcontracted at the time to produce the Pratt & Whitney R-2800 series engine, which was a common engine in the navy's carrier fighters and medium bombers. The Grumman F4F *Wildcat* operated with the Pratt & Whitney R-1800 and the newer F6F *Hellcat* was being built with the R-2800. Initially, Dearborn seemed like a perfect location for technicians to received specialized engine training. However, it was soon discovered that Ford's curriculum did not correspond to the navy's for Aviation Machinist's Mates.[186]

The four-month course was specific to the R-2800, thus it lacked training in other general duties of the AMM rating such as aircraft characteristics, hydraulics, fabric, and basic ordnance. The navy did not operate like a mass production plant. Aircraft technicians were required to be a part of any and all evolutions on ship or shore, not limited to one part or system of the vehicle like automobile manufacturer labor. For this reason, graduates of Dearborn often failed the follow-on examinations required of Aviation Machinist's Mates once they checked out of Ford's school and reported back to their parent training command. Dearborn graduates were extremely knowledgeable in the operation and repair of the R-2800 engine but little else. It was for this reason that BuAer eventually abandoned the school as a program for Aviation Machinist's Mates,

[186] Haley, 8.

but the navy retained Ford's services and facilities for more general fleet technician education on different types of gas and diesel engines, electrical systems, and a variety of other systems. Dearborn was capable of housing 900 students at any given time during the war until its closure in May 1946.[187]

After Pearl Harbor, some of the schools where enlisted aviation technicians were learning their trade were closed or thinned out to make room for increased pilot and general aviation training. NAS Pensacola transitioned to a primary flight training center and the technical schools it once hosted were disbanded completely as pilots and navigators filled the former enlisted barracks and mess halls in for flight training. In 1942, BuNav had formally changed it title to the Bureau of Naval Personnel (BuPers) to better reflect its mission. By that spring, BuAer and BuPers had a relatively concise list of service schools that were doing their best to satisfy the requirement of the aviation navy. Until World War II, the U.S. Navy had never really concerned itself with standardized courses of instruction for its aviation technicians. Following a period of trial and error at the end the interwar years, BuAer and BuPers finally settled on a uniform length of study in each of the aviation ratings by 1942.[188] The standard time frame from start to finish for "A" schools was either four or six months. To put this into perspective, the average length of the basic aircraft mechanic course given by the Army Technical Training Command in 1942 was eighteen weeks. Between 1938 and 1942 the

[187] "Rouge Naval School Trained WWII Sailors in Skilled Trades," *The Detroit News*, May 1, 2004, http://blogs.detroitnews.com/history/2004/05/01/rouge-naval-school-trained-wwii-sailors-in-skilled-trades/; Haley, "Historical Report of the Technical Training Section through December 1943," 8.
[188] See table 3-3.

Army also expanded the number of its technical aviation courses from three to twenty-two.[189]

The navy's length of schooling was consistent across the board due to the overarching efforts to standardize the curriculum. The navy finally had a refined technical training program for its technicians that operational commanders could use to project the arrival of their next wave of freshly trained maintainers. Table 3-3 depicts the schools and length of instruction in April 1942:

Table 3-3: Length of Curriculum by School and Rating[190]

Rating	School Location	Length of Course
Aviation Machinist's Mate	NAS Norfolk, NAS Seattle, NAS Jacksonville NAS Alameda	6 months
Aviation Machinist's Mate	NTS Great Lakes NTS Dearborn	4 months
Aviation Metalsmith	NAS Jacksonville NAS Seattle NTS Navy Pier NAS Alameda	6 months
Aviation Radioman	NAS Jacksonville, NAS San Diego NAS Seattle NAS Alameda	4 months
Aviation Ordnanceman	NAS Jacksonville NAS San Diego NAS Seattle	4 months

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In 1942 the technology of naval aircraft was advancing far beyond anything technicians had seen during the interwar years. The navy sought to compartmentalize its

[189] "The Technical Training Command's Maintenance Program," *Aviation*, July 1942, 236. The 22 schools included non-aircraft mechanic subjects such as weather forecasting, photography, parachute rigger, etc.
[190] Haley, "Historical Report of the Technical Training Section through December 1943," 6.

labor force to keep up with the changes. Some aviation ratings tended to have a bigger workload than others. For example, an AMM was required to know the intricacies of almost every moving part on an airframe, including engines, propellers, and hydraulics. The Aviation Radio Technician (ART) was an expert with the radio, its operation, inner electronics, antenna, and so forth.[191] All ratings were important to the success of naval aviation, but not all ratings were as critical to the safety of the aircrew as others were.

Certain ratings required a longer period of schooling because of the volume of material and critical nature of their work. If an engine was repaired incorrectly, a second chance after failure in flight was unlikely. The Aviation Machinist's Mate and Aviation Metalsmith "A" schools took an average of two months longer than other aviation ratings. Additionally, these two ratings made up the majority of the navy's enlisted aviation technician force, therefore it was imperative that the Trade Schools find a way to graduate more technicians in less time.[192] These technicians were responsible for maintaining navy aircraft from the its nose to its tail. While an airplane could safely takeoff and land with an inoperable radio or a faulty bomb rack, one cannot say the same thing about a malfunctioning engine or major delaminating surfaces on the skin of an airplane.[193] Ratings that focused on aircraft systems that were "safety-of-flight" systems tended to be in greater demand and required a longer term of instruction. Even with a standardized curricula and predictable matriculation of newly qualified technicians, the navy was still not meeting the needs of the Fleet. Wheelock suggested to Towers that

[191] Headquarters, Naval Air Technical Training Command, *Technicians' War: A Picture Story of U.S. Naval Air Technical Training Command*.
[192] See table 3-2.
[193] ART rating specialized in maintenance of aircraft radios. AOs were responsible for aviation ordnance including the delivery systems built into the aircraft. Engines and aircraft skin refer to AMM and AM ratings responsibilities.

more extreme measures were required in support of technical training in the face of the wartime crisis.[194]

On 16 April 1942, Towers submitted a recommendation to the CNO and the Secretary of the navy for the establishment of two new Class "A" schools to supplement the schools currently in existence. His plan called for the Bureau of Yards and Docks to construct two large training centers away from coastal naval air stations that could handle 10,000 students each. Memphis, Tennessee and Norman, Oklahoma were chosen as the sites for the new training centers.

Tower's recommendation was approved by the Secretary of the Navy on 24 April 1942. The initial funding for the project, an amount of $25,000,000, was approved by Congress in the National Defense Act of 1942. Coordination with local and state governments began immediately, and by late July, the navy had already established a temporary headquarters space in a downtown Memphis office building.[195]

The Naval Training Center (NTC), Norman, Oklahoma was commissioned on 20 September 1942. NTC Memphis was commissioned three days later on 23 September. Both facilities were designed as "Aviation Maintenance" centers, thus designating their curriculum for AMM, AM, ARM, and AO ratings only. A month prior, the CNO had requested that BuPers transfer all staff, students, instructors, and equipment from the Aviation Machinists' Mate School at Norfolk and the Aviation Ordnanceman's School in San Diego to NTC Memphis by 1 October and 15 October. The Aviation Machinists' Mate Schools in Alameda, Seattle, and San Diego; the Aviation Metalsmiths' Schools in

[194] Bureau of Aeronautics, "Aviation Personnel and Training," 1959, 323–24.
[195] "NATTC Memphis," 1945, 1, Aviation Commands, 1941-52, AR/180, Box 240, NHHC; Haley, "Historical Report of the Technical Training Section through December 1943," 7.

Alameda and Seattle; and the Aviation Ordnanceman's School in Seattle were all ordered to do the same beginning in September 1942. These transfers were based on BuPers approval of earlier recommendations by Wheelock's Technical Training Section that the navy should consolidate its major aviation technical training centers into four geographic locations: Jacksonville, Chicago, Memphis, and Norman. [196]

Even with the ability to have 37,237 aviation technicians undergoing training at any given time, the navy was still unable to meet the requirements of the Fleet.[197] At the end of the fiscal year, within a week of the navy's two newest technical training centers openings, Wheelock's section recommended that Memphis, Norman, and Jacksonville increase their student load capacity. Memphis and Norman expanded their facilities from 10,000 to 15,000 students, and Jacksonville increased its capacity by 800. BuAer and BuPers were doing their best to manage the ever-increasing workload of getting quality aircraft technicians out to the Fleet in 1942.[198] However, no matter how hard they tried, and how many revisions they made to original plans, the numbers still fell short.

There was one other system in place at the start of the war that provided the specialized education necessary for naval aviation personnel on aircraft systems. A small program was put into place in 1941 that sent select petty officers to aircraft or aircraft parts factories for limited, streamlined training. This was based on an agreement between BuAer and BuPers that BuAer would recommend a few key personnel on an irregular basis to study with factory engineers and artisans for a short period of time. Essentially,

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[196] Haley, "Historical Report of the Technical Training Section through December 1943," 7; "NATTC Memphis," 2.
[197] The figure 37,237 was the maximum student load that BuAer reported to SECNAV in a memo dated 16 April 1942. As referenced in Haley, "Historical Report of the Technical Training Section through December 1943," 7.
[198] Data herein contained in a BuAer Letter dated September 15, 1942; Haley, 7.

it was temporary assigned duty to a factory for a few days to a few weeks of training. This training varied from engines, to aircraft weapons systems, servicing equipment, aircraft structures, and aircraft instruments. There were no regular courses or a standard curriculum for each system. But nonetheless, after the brief period of hands-on instruction, sailors returned to their commands with a better knowledge of the latest equipment on the flight deck.[199]

The factory training program continued to grow throughout 1941 and into the following year. BuAer was pleased with the results and began to explore options to incorporate it on a larger and more routine scale. In one instance, BuAer's Personnel Division coordinated with Pratt and Whitney to develop a consistent program of twenty technicians per month, all housed at the factory at no cost to the navy. Often the manufacturers themselves reached out to BuAer or BuPers and offered their services at little or no charge. This program was relatively successful and grew throughout its inception and into the spring of 1942. Ultimately, BuAer's Technical Training Section under Wheelock made the pitch to have navy barracks built at certain factories. Wheelock anticipated future growth of the program and requested Towers' approval. Towers did not support such a "permanent" agreement with factories and thus rejected Wheelock's plan. He did, however, establish a policy that encouraged the continued use of the factory training programs. Towers had a few stipulations, including that the maximum student load from the navy be limited to fifty men per month, and the length of training period should not exceed one month.[200] Factory training was a valued program, but not a robust one.

[199] Haley, 13.
[200] Haley, 13.

Additional factory training arrangements were made with wartime manufacturers. The decision to formally enter into contract with a manufacturer was not an easy one. In April 1942, Towers recommended that BuPers contract with the Curtis-Wright Corporation to provide a more in-depth education into the nuances of the newly developed SO3C *Seamew* observation seaplane. Towers proposed that Curtiss conduct training for four men per squadron and BuAer manage the training through its co-located Naval Aircraft Inspectors. He expected that BuPers would fund it. BuPers did not agree on the basis that entering into subsequent contracts with companies already in production contracts with the navy was legally inadvisable. However, since most factory training was relatively small and usually was furnished without charge to the navy, a formal contract was not really necessary. Therefore, the BuAer Technical Training Section chose to manage the training and small contracts (if any) with the few companies that were in production for BuAer. Goodyear Tire and Rubber Company, Lockheed Aircraft Corporation, and the Douglas Aircraft Corporation were some of the more prominent companies that provided training *pro bono*.[201]

As the number of small contracts grew, BuAer sent a request to the Navy Paymaster General suggesting that the training costs be absorbed into the production contracts. The Paymaster General agreed, and notified current and future manufacturers that the expense of training key squadron personnel was to be considered tied directly to the delivery of new equipment and any cost therein should be included in the total cost of

[201] Haley, 14; Bureau of Aeronautics, "Aviation Personnel and Training," 1959, 340–44.; *Pro bono* services by companies such as these were not as selfless as they might have appeared. Often manufacturers received such lucrative incentives from the government to expand production and meet wartime demands, that providing factory-run training for the Navy made little impact on the profits of their "cost-plus" contracts. For more or this topic I recommend Eugene E. Wilson's, *Slipstream: The Autobiography of an Air Craftsman*, (Literary Investment Guild: Palm Beach, FL), 1967 and *The Grumman Story* by Richard Thruelson (Praeger: New York), 1976.

the aircraft or associated equipment.[202] These contractual actions afforded BuAer more opportunities to acquire specialized training for its technicians. By September 1942, thirty factories were providing instruction to navy personnel in conjunction with production contracts. Regular quotas were setup with large aircraft manufacturers such as Grumman, Douglass, Vought-Sikorsky, and Curtiss-Wright. Soon these companies began to develop syllabi that, in turn, were sent to BuAer for recommendations and comment. This way the navy had some input into the methods in which its aviation technicians were trained.[203]

As the technology of aircraft systems matured, the number of small training courses grew. The administration of such programs began to weigh heavily on not only Wheelock's staff in the Technical Training Section, but on CAPT Radford's Training Division as a whole. The aviation technical training program was growing into a colossal, multifaceted activity that was becoming more difficult to manage each day. The training of aviation technicians needed its own command and dedicated staff. Captain Radford's Training Division had more than it could handle managing the in-air, on-ground, and technical training of the entire navy. A forthcoming major change in the administration of such duties was about to permanently revise the role of BuAer in the navy.[204]

[202] Bureau of Supplies and Accounts, Letter of 14 September 1942. As referenced in Haley, 15.
[203] Bureau of Aeronautics, "Aviation Personnel and Training," 1959, 343–44.
[204] Haley, "Historical Report of the Technical Training Section through December 1943," 14–16; Bureau of Aeronautics, "Aviation Personnel and Training," 1959, 353.

Chapter 4: Paradigm Shift

As the navy's operational activity intensified throughout 1942, the demands of the war compelled the navy's bureaus to deliver unprecedented output. The Bureau of Naval Personnel was heavily engaged in procuring men to outfit ships, aircraft, and submarines. The Bureau of Ordnance was trying to acquire the requisite number of weapons to outfit every ship and airplane with state-of-the-art armament. The Bureau of Yards and Docks was struggling to build up enough infrastructure overseas and within the United States to support the ever-growing fleet. The Bureau of Ships was heavily engaged in design and ship construction. BuAer was still trying to manage all facets of the aviation training programs, in addition to the procurement and maintenance of new aircraft. In particular, the Aviation Training Division of BuAer was overburdened with the having to solve numerous and difficult problems related to technician and pilot training. BuAer found the ever-increasing number of personnel and complexity of the instruction programs overwhelming. In response to this situation, Towers responded with a change in BuAer's administrative structure.[205]

Until September 1942, all aviation training activities (pilot and technician) were managed under BuAer authority, but supervision of the physical facilities or bases themselves was overseen by the Commandant of each particular Naval District. For example, the 9th Naval District included Chicago, and its Commandant had direct control of all Naval facilities within its geographical boundary. As the trade schools tried to accomplish the herculean task of training so many technicians, the necessary expansion

[205] Haley, "Historical Report of the Technical Training Section through December 1943," 15.

of instruction facilities required increases in funding. In order to secure additional fiscal resources, the trade schools had to go outside the BuAer chain of command and seek approval of the District Commandant. This process ultimately became unworkable simply because Commandants had many other responsibilities and fiscal demands to meet. In addition, the Commandants themselves were not aviators and had little familiarity with the complicated and extensive requirements of aviation training and maintenance, which meant that essential needs of a naval air force did not receive priority.[206]

In December 1940, Congressman Melvin J. Maas of Minnesota and Captain Marc A. Mitscher spent two weeks touring the navy's shore aviation training facilities as a subcommittee of the Naval Affairs Committee. Maas reported back to the Chairman, Congressman Carl Vinson of Georgia, that the majority of the enlisted barracks and facilities were unsatisfactory. Both Maas and Mitscher believed that the procedure of requiring "administration of personnel and assignment and general policy" to be cleared through non-aviator district Commandants was the main reason for such poor conditions. They recommended administrative duties be placed under the cognizance of BuAer instead of the Commandants.[207]

Little was done, however, to remedy this situation over the following year. As a result, BuAer's Technical Training Division was eventually overwhelmed with the demands of numerous schools spread out over multiple locations. Wheelock observed in late 1941 into early 1942 what Maas and Mitscher had noticed a year earlier—the

[206] Bureau of Aeronautics, "Aviation Personnel and Training," 1959, 353–54.
[207] U.S. Congress, House of Naval Affairs Committee, *Sundry Legislation Affecting the Naval Establishment*, 77th Cong., H. Doc. No. 4, 1940, (Washington, 1942), 133.

inadequacies of assigning management of aviation operations at the training sites to the District Commandants. He noted, in particular, that the allocation of appropriate funding for the trade schools was in competition with the other training and shore-based activities, which were not necessarily aviation-related. Wheelock suggested that in order for the technical training to run more efficiently, a separate command should be established. An autonomous command could operate the technical schools independently from the District Commandants, thus relieving them from the administrative headache of managing both the naval base facilities and technical aviation schools. Wheelock's plan would also centralize the command authority of the technical trade schools. Wheelock believed that a single unified authority could better manage the technical education across the geographical and bureaucratic jurisdictions than asking the various Commandants to respond to BuAer and BuPers' training requirements.

On 11 September 1942, the Secretary of the Navy issued a letter establishing the Naval Air Technical Training Command (NATTC) as its own authority, directly under the Secretary of the Navy. NATTC did not fall under the jurisdiction of BuAer or BuPers, but was chartered to work in conjunction with the two Bureaus. By November, BuAer transferred all but four personnel from the Training Division of its Technical Training Section to NATTC. Wheelock, recently promoted to full Commander, remained behind with three others to function in a liaison capacity between BuAer and NATTC. At this time, the BuAer Technical Training staff had developed into a robust group of professionals developing training films, curricula, and technical manuals. But, the task of disseminating these materials throughout the various trade schools was a significant

administrative burden for BuAer. Thus, transferring this responsibility along with the outgoing Training Section made the most sense.[208]

Wheelock's Training Division had had become well versed in negotiating the bureaucratic maze of the Navy Department. A significant part of their job had been to formulate accurate estimates that would ensure that the proper amount of funding for aviation technical training was requested in the annual BuAer budget. To his credit, Wheelock had become accustomed to the consistent fiscal requirements that accompanied facility maintenance and daily operations at the trade schools, as well as the significant costs of providing training materials such as books, films, and aircraft models.[209] This administrative skillset was extremely valuable, and would undoubtedly serve the newly-formed technical training command.

With the establishment of NATTC, Wheelock was made the primary liaison between BuAer and the NATTC. This was a good decision. Wheelock's fiscal sense and administrative expertise that made him such an invaluable asset to both commands. His role as liaison limited the burden on the NATTC staff in terms of budget requests and estimates. Wheelock immediately folded the financial needs of NATTC into BuAer's supplemental budget requests beginning Fiscal Year (FY) 1944, since inputs for FY 1943 had already been submitted by the time NATTC was established. Wheelock's actions allowed the NATTC staff to focus their efforts more on the immediate task of training and to avoid the distraction of budget estimates and materiel procurement.[210]

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[208] Bureau of Aeronautics, "Aviation Personnel and Training," 1959, 358–59.
[209] Haley, "Historical Report of the Technical Training Section through December 1943," 18; Bureau of Aeronautics, "Aviation Personnel and Training," 1959, 360.
[210] Haley, "Historical Report of the Technical Training Section through December 1943," 18–19.

The Secretary of the Navy's letter, establishing the NATTC as a separate command, specifically stated that "within each naval district, all activities specifically and exclusively assigned to an Air Functional Training Command shall be excluded from the jurisdiction of the Commandant of the District."[211] The Chief of Naval Aviation Technical Training Center (CNATTC) reported directly to the Vice Chief of Naval Operations (VCNO), not the Chiefs of BuAer or BuPers.[212] This allowed NATTC to make its own decisions and run its own affairs on the bases where the trade schools were housed. As shown in Table 4-1, the enlisted technical schools were located throughout the country, spread out over ten states. The logistical challenge of trying to communicate individually with each District Commandant was an unnecessary burden for BuAer's Training Division. Consolidating administrative control under a single central authority helped to ease that burden.

Table 4-1: Enlisted Technical Schools as of September 1942[213]

ENLISTED Schools	**Location**	**Location**	**Location**	**Location**	**Location**	**Location**
Naval Training School (Aviation Maintenance)	Jacksonville FL	Navy Pier, Chicago, IL	87th and Anthony, Chicago, IL	Memphis, TN	Norman, OK	Dearborn, MI
Naval Training School (Advanced Aviation Maintenance)	87th and Anthony St., Chicago, IL					
Parachute Material School	Lakehurst, NJ	San Diego, CA	Corpus Christi, TX			
Bombsight Maintenance School	Dahlgren, VA	San Diego, CA	Jacksonville, FL	Norden Factory, New York, NY		

[211] Haley, 16.; SecNav letter of September 11, 1942 included two other newly established training commands. The Naval Air Primary Training Command and Naval Air Intermediate Training Command were responsible for pilot flight instruction. All three commands were given the same autonomy to operate independently of the District Commandants.
[212] "What Is the Naval Air Technical Training Command:," VI.
[213] Haley, "Historical Report of the Technical Training Section through December 1943," 16–17.

Aerographers' School	Lakehurst, NJ					
Photographers' School	Pensacola, FL					
Instrument Schools	87th and Anthony St., Chicago	Sperry Gyroscope Company, Brooklyn, NY	Sperry Gyroscope Company, El Segundo, CA			
Link Trainer Schools	Pensacola, FL	Naval Reserve Aviation Base, Atlanta, GA				
Aviation Radar School	Ward Island, TX					

Fortunately, the schools were already established and NATTC only became responsible for taking over where BuAer had left off. However, in doing so, NATTC had to accept full responsibility of all technical training. This included more than just the enlisted schools. Officer technical training also fell under NATTC's responsibility, which it in itself was no small logistical task either. Note in Table 4-2, that Officer schools were also dispersed throughout the country.

Table 4-2: Officer Technical Schools, September 1942.[214]

Officer Schools	**Location**
Indoctrination	NAS Quonset Pt., RI
Indoctrination & Photography	NAS Pensacola, FL
Teacher's Training Center	Chicago, IL
Air Combat Intelligence School	NAS Quonset Pt., RI
Air Operations School	NAS San Diego, CA; NAS Norfolk, VA
Fighter Direction School	Naval Base Norfolk, VA
Gunnery Officers' School	NAS Jacksonville, FL
Engineering Officer's School	Pratt & Whitney Company

[214] Haley, 17.

Whether training was conducted at public universities, private colleges, manufacturers' plants, commercial airline schools, or Civil Aviation Administration (CAA) schools, it all fell under the responsibility of NATTC. The administrative burden placed upon the newly established command was colossal, and it would take someone with exceptional management ability and substantial aviation experience, to lead the navy's aviation technical community through uncharted waters.

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Rear Admiral Albert Cushing Read was chosen as NATTC's first Chief. Read and Towers had a relationship that dated back to two decades. Read was the famed commander of seaplane NC-4 in 1919 that completed the first transatlantic crossing by air. Towers had been the overall commander of the operation, which consisted of four total aircraft, but Read's plane was the only one to complete the flight by air. Read's career was fairly ordinary throughout the interwar years, but his long-standing relationship with Towers most likely had some influence on his selection as the first Chief of NATTC.[215]

Administratively, the greatest impact that NATTC's creation had was on the financial arrangement between the Department of the Navy, BuAer, and BuPers. Prior to 1 January 1943, all funding for the operation and maintenance of aviation training schools had been funneled through the District Commandants. After 1942, BuAer and BuPers no longer had to compete with the Naval Districts for funding. Now Read, from

[215] For the most informative account of NC-4's crossing and Read's relationship with Towers, see Richard K. Smith, *First Across! The U.S. Navy's Transatlantic Flight of 1919* (Annapolis, MD: Naval Institute Press, 1973) and Clark G. Reynolds, *Admiral John H. Towers: The Struggle for Naval Air Supremacy* (Annapolis, MD: Naval Institute Press, 1991).

his headquarters in Chicago, could appropriate his monthly and yearly funds when and where it was needed most. NATTC funding was allocated from both BuAer and BuPers budgets, based on the requisite monthly estimates.[216]

In order to differentiate which funds came from which budget, the Secretary of the Navy's instruction provided that any technical training activities that were geographically located on a naval air station were to be funded by BuAer funds, designated from the Congressional appropriation "Aviation Navy." All other funding for technical aviation training activities not specifically located on a Naval Air Station were provided in the "Instruction Navy" designation within the BuPers budget. This new method of administering finances for training purposes was a centralized partnership between the two Bureaus. It placed the budgetary structure of NATTC on a well-defined and stable administrative footing. Training budgets had been a part of the navy since its inception. It was not until 1943 however, that the problem of distinguishing between technical aviation naval training and technical surface naval training became a concern. The potential for misadventure was enormous when two different bureaucratic entities were responsible for various aspects of a single form of training. Yet, thanks to Wheelock and others who appreciated the importance of understanding *who pays, how much, and why,* the navy took an innovative step in the right direction when it came to aviation technical training in World War II.[217]

Once NATTC had full cognizance of the technical training program, changes followed. One of Read's first actions was to eliminate the civilian Teacher Training

[216] Haley, "Historical Report of the Technical Training Section through December 1943," 19.
[217] Haley, 19.; I am indebted to Professor Jon T. Sumida, PhD for introducing me to the phrase *who pays, how much, and why* in his undergraduate course on the history of early warfare (HIST 224) at University of Maryland, College Park in 2015.

Program which had already had its funding cut back by Congress in 1942. The program, a partnership with the U.S. Department of Education that trained civilians to be instructors at the aviation technical schools, was a financial burden on the navy. It had also caused a rift between civilian and active duty instructors over pay rates; civilians were paid more than their enlisted equals. Read wasted no time in formally requesting the program's discontinuation. As the approving authority, BuPers had to agree and make the formal decision to terminate the program. By 1 January 1943, the facilities in Chicago that housed the program were emptied of civilian instructors and were opened up to additional classes for advanced technical training.[218]

The period that followed NATTC's installment as an individual command brought with it changes in the structure of the technical training program for the aviation navy. Within six months of operating as an independent command, NATTC reorganized the numerous schools into four different groups based on who made decisions with regards to training matters. Group I Centers were designated a separate Command with its Commanding Officer directly under the Chief of NATTC. Group II Centers were also a separate Command, but were located within the physical limits of a larger Naval Establishment, what could be considered a "tenant command."

Tenant commands were essentially a command within a command. It was usually a smaller unit that had its own administrative structure to include a Commanding Officer, responsible to another senior officer located in another geographic location. For example, Group II Commanding Officers had to follow the local regulations and orders that the Naval Base Commander had promulgated, but in terms of technical training,

[218] Haley, 20.

graduation rates, or specific training issues, they would report directly to Admiral Read, Chief of NATTC.

Group III Schools were not considered Commands, but as their title indicated, a school. These schools were located on a base or other establishment that did not possess any other NATTC facilities. The military commander of such an establishment had authority over military matters while CNATTC had charge over all training matters. An Officer-in-Charge (OinC) was in place locally as CNATTC's direct administrative representative at each Group III School. Similar to Group III, Group IV Schools were small-specialized training schools or factories located at other-than-navy facilities, like U.S. Army bases. CNATTC still had cognizance over all training matters *via* an OinC.[219]

The change in schooling was a major accomplishment. By 1944, NATTC had consolidated most of the technical training schools for enlisted personnel—primarily Group I and II activities—into six geographic locations. Class A schools were designed to give basic training to sailors in the first round of schooling and prepare them to carry out the duties of a third class petty officer. Class B schools consisted of more advanced training and were designed to prepare technicians for higher petty officer rankings. Class C schools only trained technicians on unique subjects or skills, omitting the full requirements for advancement like the other schools taught. "C1" denoted that the school was located at a Naval establishment, whereas "C2" signified that the school was part of a manufacturing plant facility.[220] Class P schools provided follow-on training at the

[219] Haley, 20; "What Is the Naval Air Technical Training Command:," VI.
[220] Headquarters, Naval Air Technical Training Command, *Technicians' War: A Picture Story of U.S. Naval Air Technical Training Command*, sec. Specialized Training.

basic or preparatory level. The following two figures illustrate each separate category of activity and which schools were characterized under its classification:

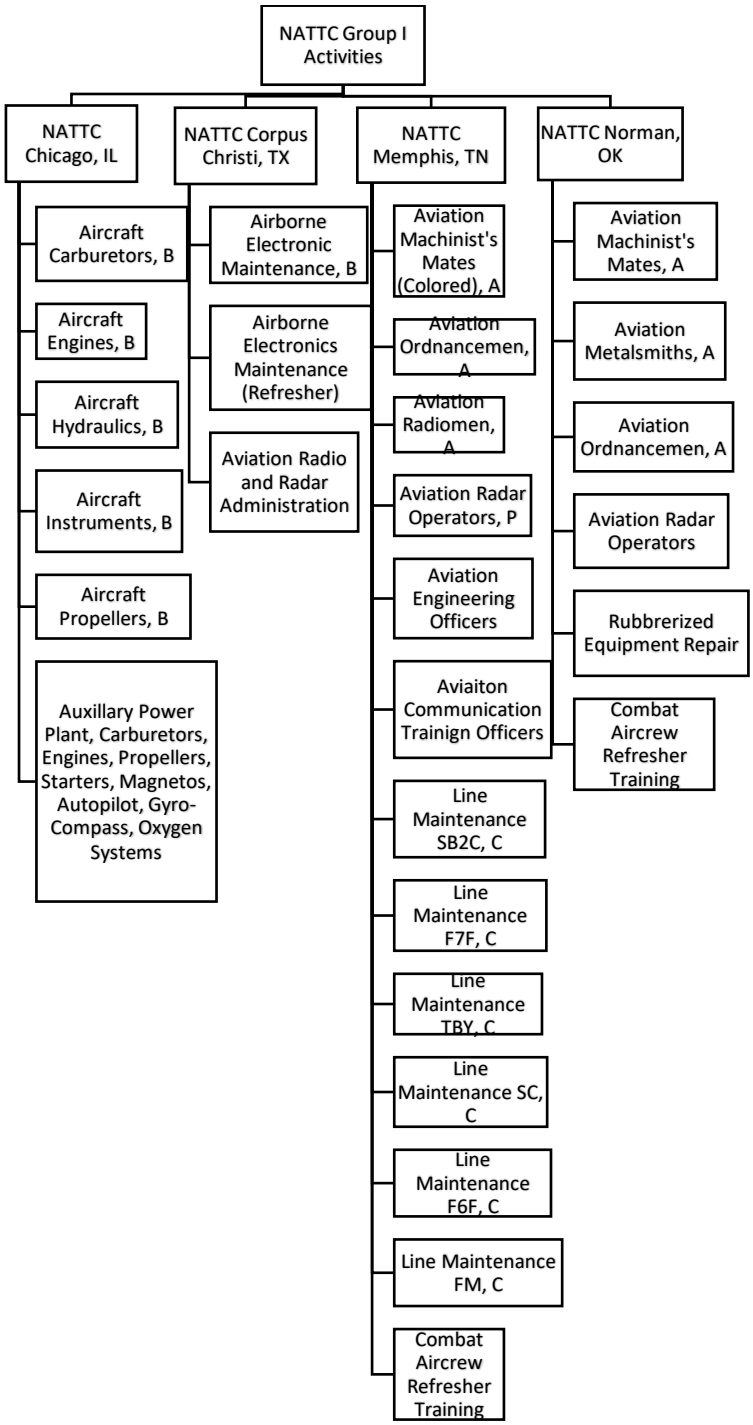

Figure 4-1: Group I NATTC Activities[221]

[221] "Organizational Chart of Naval Air Technical Training Command," December 15, 1944, WWII Aviation Training, Box 68, NHHC.

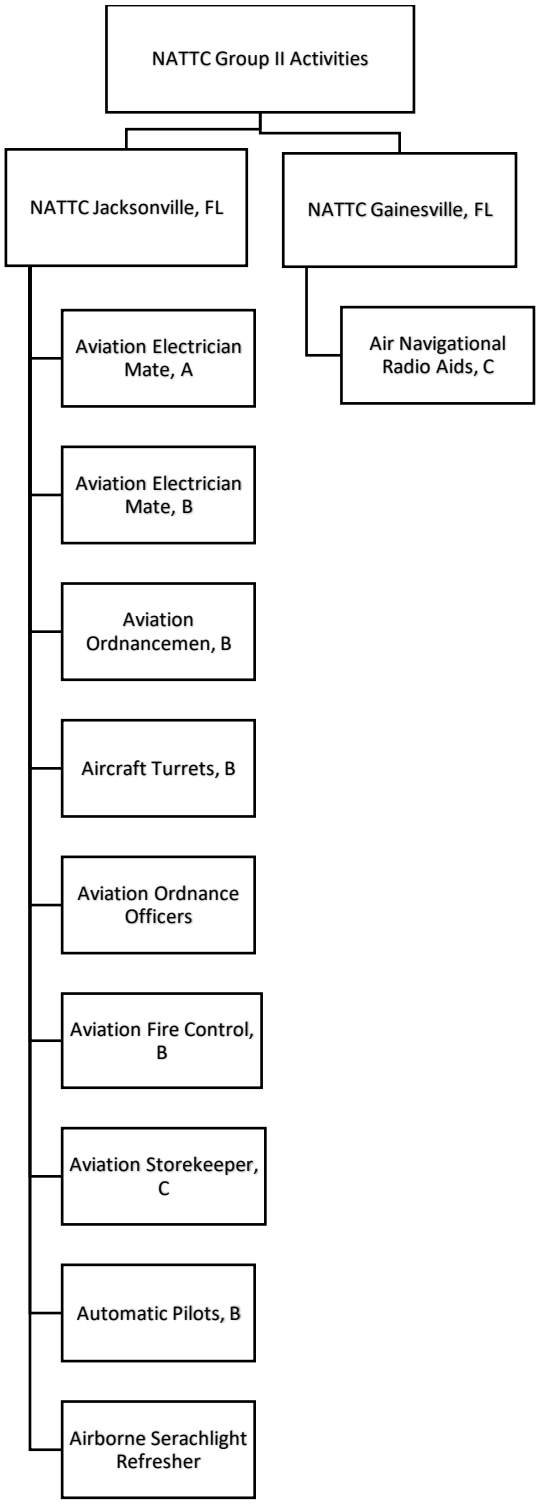

Figure 4-2: Group II NATTC Activities[222]

[222] "Organizational Chart of Naval Air Technical Training Command."

Group III NATTC Activities consisted of schools that were focused more on supporting aircraft flight operations than on aircraft maintenance. Schools for Aerographers, Parachute Riggers, Control Tower Operators, and Photographers were included in Group III. There were a few other technical schools lumped in with the others such as a segregated Class "A" Aviation Metalsmith School at Great Lakes Naval Training Center designated for African-American sailors only, and a Turbo-Supercharger Regulator Course at the Naval Air Station in Minneapolis, Minnesota. Slightly less than twenty Group III schools were operating in 1944. They were generally either Class A or C1 in design, if they were designated at all.[223]

[223] Headquarters, Naval Air Technical Training Command, *Technicians' War: A Picture Story of U.S. Naval Air Technical Training Command*, sec. Specialized Training; "What Is the Naval Air Technical Training Command:," 5–6.

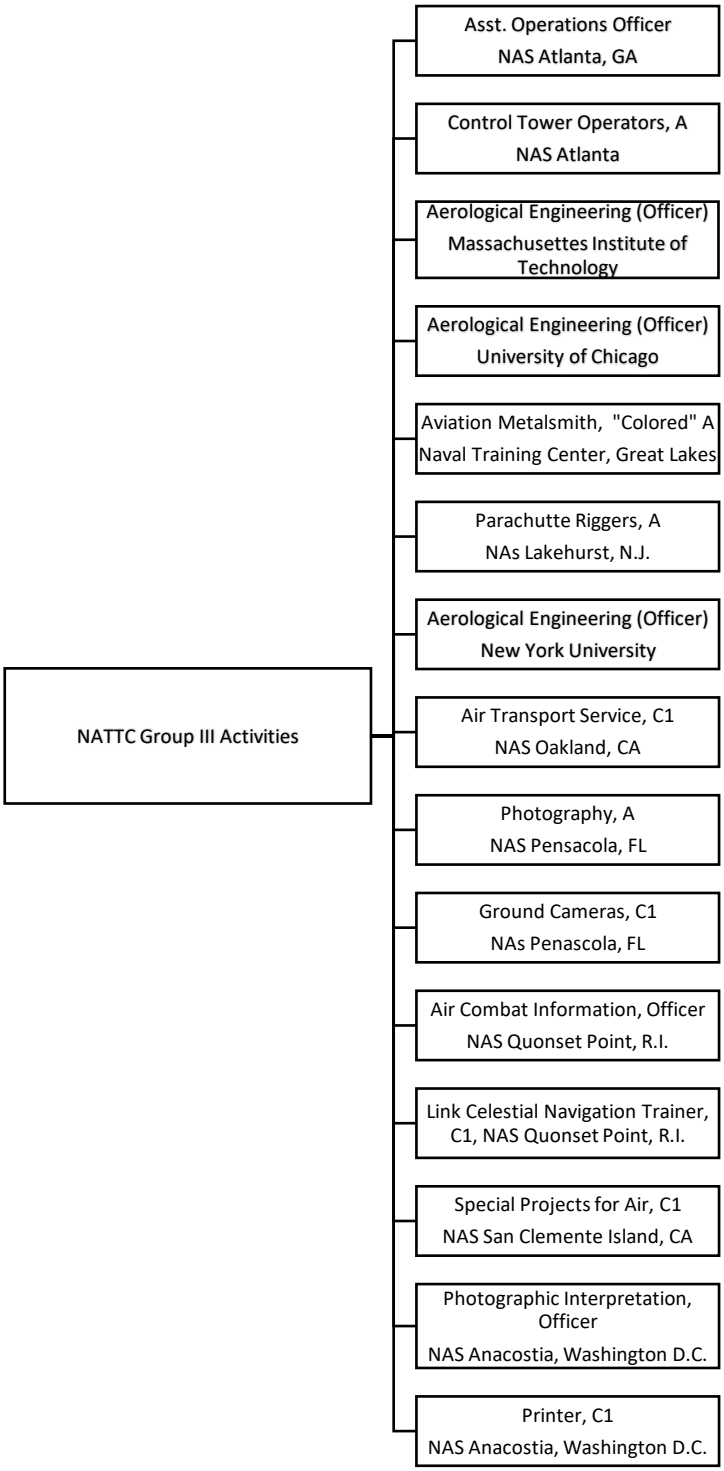

Figure 4-3: Group III NATTC Activities[224]

[224] "Organizational Chart of Naval Air Technical Training Command."

NATTC Group IV activities varied in location and subject. Figure 4-4 is a depiction of Group IV activities that were in existence by the end of 1944. At this point, NATTC operations were well-established and consistent with BuAer's previous emphasis that both commercial and public facilities be utilized to provide specialized training for aviation technicians. Prior to World War II, there were more than 100 of these specialized manufacturer schools in existence. After NATTC was established in 1942, the number of these schools decreased as the navy-operated schools became the mainstay of technical education. However, it was still routine throughout the war that technicians with the potential to be billeted into a teaching role either at a technical school or in the Fleet would be sent to these manufacturer-operated schools.

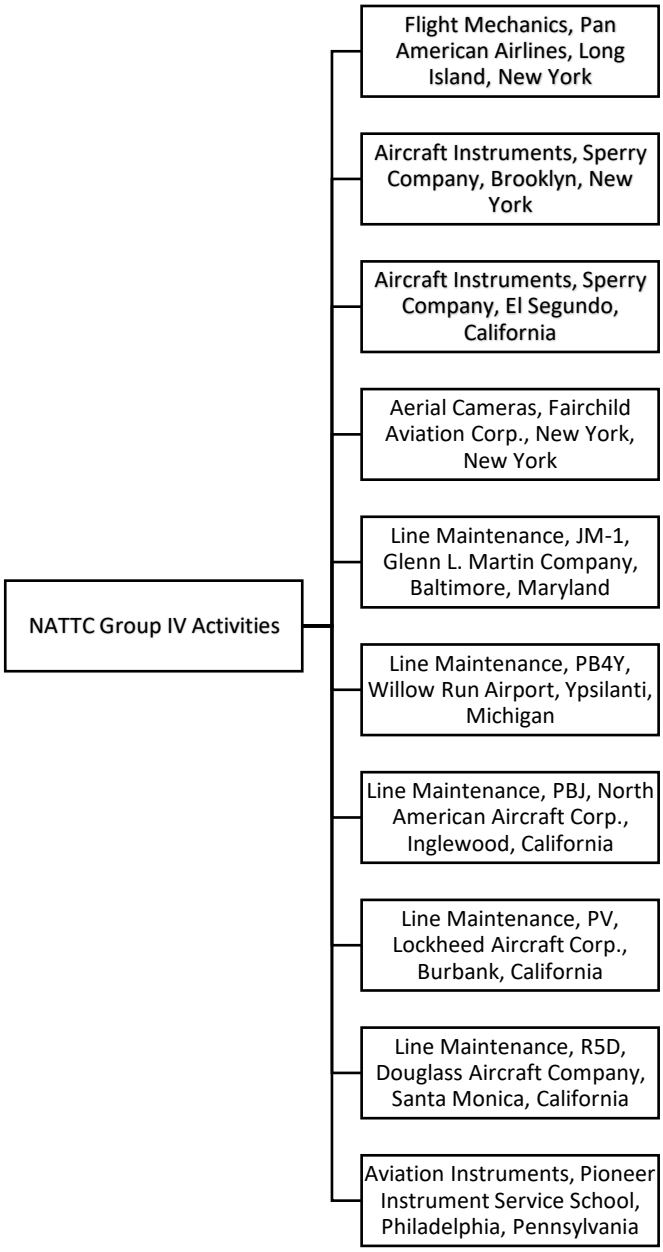

Figure 4-4: NATTC Group IV Activities as of 15 December 1944.[225,226]

[225] "Organizational Chart of Naval Air Technical Training Command."
[226] All aircraft listed were flown by the U.S. Army Air Forces under a different designation: JM-1 was also known as a B-26, a PB4Y was designated a B-24 in the AAF, the PBJ was a B-25, and an R5D corresponded to a C-54. Thus, it can be assumed that manufacturer training schools supported the Army technicians as well. For a complete list of aircraft that were flown by both the Army and Navy, see DCNO (Air) World War II Administrative History, Volume 22, "Aviation Personnel, 1939-1945" Appendix A

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BuAer Training Section's reformation of technical training schools under Wheelock, and ultimately NATTC, was successful. But what good were school houses without curricula? The experience and knowledge in authoring technical aviation instruction books that LCDR Daniel J. Brimm brought with him was just what BuAer needed to remedy the problem. Prior to 1941, there were only three small booklets supplying all the technical knowledge an aspiring Aviation Machinist's Mate was expected to know before joining the fleet forces.[227] There was also the *Bureau of Aeronautics Manual* published every year that contained a few sections on maintenance. The 1940 edition contained the many technical chapters with general instructions on routine upkeep, repair, and inspections. However, it was not specific to any one aircraft.

The older material was written in such a way to suit a broad audience without getting too far into the details of maintenance procedures that varied between aircraft type. For example, in the nineteen-page "Propellers" section located within the "Miscellaneous Equipment" chapter, there is one page on repairs, one on corrosion, one on pitch settings, and two pages on balancing. Other subsections include hubs, service settings, inspection, and a few paragraphs on how to substitute a different model propeller when the original manufactured equipment was not available. The section ends with a paragraph stating that manufacturer manuals were the primary source of information, "The Bureau intends that the service make full use of information and instructions contained in propeller manufacturers' manuals … and that the instructions contained therein relative to inspections, operation, and maintenance of propellers be

[227] Bureau of Naval Personnel, "Training Activity," in *Administrative History of World War II: Bureau of Personnel* (Department of the Navy, 1959), 287.

observed in all cases …"[228] Other chapters within the manual discuss maintenance and operating instructions of power plants (engines) , general operating maintenance, aircraft instruments, radios, electrical equipment, repair and overhaul, aircraft markings, and storage. The 1940 manual also contains a nine-page discussion on supply, stores, and transfer of parts along with a general description of BuAer publications and standard reporting and record keeping procedures.[229]

As Brimm settled into his job at BuAer, four new texts were quickly published for naval aviation technicians, two for aviation metalsmiths and two for aviation ordnancemen. The seven text books BuAer now had on hand from which to train its three primary enlisted aviation ratings was an improvement, but still insufficient to properly train the swelling numbers of young, inexperienced sailors en route to the Trade Schools. Brimm and others took note of this. More data was compiled and additional staff were brought on to assist in the development of new texts throughout 1942. Eventually, a combined officer-enlisted staff of forty was fully engaged in producing new training curricula for naval aviation technicians. By mid-1943, the textual material consisted of 14,850 pages, equating to forty-three new training manuals. NATTC had assumed responsibility for accumulating this material once the new command was established ten months prior. Most of the BuAer staff who began working on this project were placed in the NATTC organization at that time and more were added as the command matured.[230]

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[228] *Bureau of Aeronautics Manual 1940*, 1940th ed. (Washington D.C.: United States Government Printing Office, 1940), 65.
[229] *Bureau of Aeronautics Manual 1940*.
[230] Bureau of Naval Personnel, "Training Activity," 287–88.

When the final drafts of the texts were submitted to BuAer for review and approval, it was apparent that the task was much greater than BuAer could handle with its current staff. Thus, BuPers was brought alongside for assistance. As designed, BuPers had ultimate authority over all naval training courses and material, but had delegated the aviation-side of that to BuAer since the 1920s. BuPers already had billets for a Director of Standards and Curriculum and an OinC of the Training Courses Sub-unit, therefore the Bureau had experience and the capacity to manage this task. Nimitz had moved on from BuPers to run the war in the Pacific and Towers had been replaced by Rear Admiral John S. McCain. More than likely, the prior tension between the two Bureaus had transferred to the Pacific Fleet Command Headquarters in Pearl Harbor, Hawaii where Nimitz was Fleet Commander. Towers was given a third star and assigned as Commander, Pacific Fleet Air Forces (COMAIRPAC) under Nimitz. BuPers agreed to BuAer's request, but requested that NATTC be intimately involved in the process as a technical advisory or consultant role.[231]

The subject material and intent of these forty-three manuals deviated radically from what the navy had been producing. In the past, enlisted text books were published for the sailor trying to "make rate," that is, advance in rank to petty officer or higher. The older text focused on more general concepts and theories, similar to the set-up of the Bureau of Aeronautics manual. Brimm and the others moved away from this to a format that more closely resembled a subject manual for a particular part of an airplane system. The shift from rating books to single subject manuals allowed for easier revisions, a far more comprehensive discussion of the main topic, and created a more specialized labor

[231] Ibid., 288.

force better suited to the newer technology emerging in naval aviation.[232] For example, the 1945 edition of *Aircraft Metal Work* contained eight chapters: "Metal Processes," "Forming Aluminum," "Riveting," "Fasteners," "Structural Repairs," "Tanks," "Tubing," and "Plastics."[233] Another example of how detailed the training manuals had become was the *Aircraft Propellers* text book. Its chapters consisted of: "Background for propellers," "Two-position controllable-pitch propeller," "Constant-speed propeller," "Hydromatic quick-feathering propeller," "Electric propeller," and "Troubleshooting."[234] The drastic differences between what was available for study in 1940 and just five years later is indicative of the fundamental changes in the navy's overall philosophy of technical education and training.

In short, those pursuing their aviation ratings no longer had merely a single text from which to learn. The new design allowed for multiple shorter manuals that sailors could study in relationship with each other, but also independently, if focusing on a specific system. The books were also much smaller in physical size so that they could be carried around in one's hip pocket for quick reference on the job or during leisure time. The type-set was easy to read and the material was written for the technician, not the engineering scholar. Drawings, diagrams, and pictures were a mainstay throughout the manuals. Paragraphs were no longer numbered, but given titles. Standard grammar rules were applied throughout. When emphasis was needed, uppercase was substituted instead of italics. Illustrations with commentary were heavily used. The reader was addressed

[232] Ibid., 290–91.
[233] *Aircraft Metal Work* (Washington D.C.: Standards and Curriculum Division, Training, Bureau of Naval Personnel, 1945).
[234] *Aircraft Propellers* (Washington D.C.: Standards and Curriculum Division, Training, Bureau of Naval Personnel, 1945).

directly in the second person singular, making studying a more relatable experience. Historical and patriotic anecdotes were woven throughout in hopes of generating a sense of pride about one's chosen rating and justifying the challenging study undertaken. Naval aviation rating manuals adopted a more popular tone in 1943, abandoning the academic texts that had been prevalent in technical studies until then.[235]

Naval warfare communities other than aviation began to take notice of the new aviation rating subject manuals. Slowly, the rating manuals for non-aviation specialties began to adopt the style of what NATTC had done with its training manuals. In January 1944, BuPers recommended a complete overhaul of course material for established non-aviation rates. The OinC of the Standards and Curriculum Section within BuPers would have cognizance over the project. The old way of doing things was not easily overcome, as the various grades within certain rates such as Machinist's Mate had increased from four to twenty. The cost and workload of creating a separate subject manual for each grade was unrealistic in BuPers' mind. A compromise was reached in June between the progressives and old guard within the BuPers Training Unit. Rather than reproduce exhaustive amounts of repetitive material in the broader fields like machinist's mates, BuPers produced a series of five general manuals: *Basic Machines, Basic Electricity, Mathematics, Use of Tools,* and *Use of Blueprints*. These texts were based on similar volumes prepared for the aviation ratings. But in order to avoid the massive numbers of smaller separate manuals like that of the aviation community, the five texts aimed to provide a broader background of the subject matter, suitable for all rates. The popular, less-academic tone of the verbiage suited young sailors looking to promote to petty

[235] Bureau of Naval Personnel, "Training Activity," 293.

officer.[236] Thanks to Brimm, Wheelock, and the staff of NATTC, the textual material of the entire naval technical training program was designed to reach even the least educated new recruit. This, in itself, was a revolution in technical education that translated into new methods of civilian technical training after World War II.

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While NATTC was administering the classroom-side of naval aviation technical training, Wheelock's Technical Training Section in BuAer was overseeing the remarkable expansion of duties required of the Aviation Machinist's Mate and Aviation Ordnanceman ratings. The technological advances in aircraft led to increasingly complex maintenance. AMMs were required to work on much more than just engines. Hydraulics, instruments, carburetors, and other accessories all fell into their area of responsibility. AOs were charged with maintaining bombsights, bomb racks, delivery mechanisms, turrets, along with guns and the ordnance itself. Wheelock's Section identified the problem that such specialized tasks were being farmed out to technicians with the most acumen in those subject areas on a regular basis, thus keeping them from maintaining proficiency in other areas of the rating. For example, if a particular sailor had an uncanny ability for fixing carburetors, that became his primary job. By default, he or she became a specialist within the rate, but suffered when it came time to compete for promotion against other non-specialized AMMs, because the broad range of questions on the advancement exams favored those with general experience over specialists. Conversely, if a certain sailor had been sent to specialized training at a Group III or IV

[236] Ibid., 297–302.

center, and was not utilized in such a way to keep those skills proficient, the specialized training was often forgotten and wasted.[237]

BuAer's Technical Training Section identified these problems and suggested a remedy on 17 July 1943. Wheelock's team acknowledged the need for such specialists in the Naval Aviation Organization and proposed identifying or "earmarking" such specialists, so they were assigned to squadron or ship duties that coincided with their designated skillset. The Technical Training Section also recommended that the new ratings system recognize those with specialized training. New, specific ratings such as Aviation Hydraulicman, Aviation Bombsight Mechanic, Aviation Instrumentman, and others were up for discussion. The proposal was accepted by the Chief of BuAer and forwarded to BuPers for endorsement before going to the Secretary of the navy for final approval. On 27 September 1943, BuPers forwarded a revised rating structure that they had developed with BuAer.[238] The revised ratings included:

Table 4-3: Sample SECNAV Approved Additional Ratings, September 28, 1943[239]

Aviation Carburetor Mechanic (AMMC)	Aviation Flight Engineer (AMMF)
Aviation Hydraulic Mechanic (AMMH)	Aviation Turret Mechanic (AOMT)
Aviation Instrument Mechanic (AMMI)	Aviation Storekeeper (SKV)
Aviation Propeller Mechanic (AMMP)	Aircraft Painter (PTRV)
Aviation Bombsight Mechanic (AOMB)	Aircraft Torpedoman (TMV)

[237] Haley, "Historical Report of the Technical Training Section through December 1943," 26.
[238] Haley, 26–27.
[239] Haley, 26. The proposed ratings were approved by SECNAV on 28 September 1943, but not officially adopted by BuPers into the personnel system until December 1943.

The changes in rating classifications helped solve the problem of wasted training and improperly trained aviation technicians. The expansion of ratings permitted Commanding Officers, OinCs, and supervisors to gain a better understanding of each technician's particular skillset. The tendency to underutilize a sailor with specialty training became less frequent once he was identified within the rating structure.[240] These rating changes signaled that the navy was beginning to value the concept of specialization of labor in within the its aviation maintenance workforce.

In order to appreciate the drastic changes that the enlisted ranks of the aviation community underwent with regards to ratings over the course of the war, Table 4-4 lists all approved aviation ratings on 7 December 1941 and 14 September 1945:

Table 4-4: SECNAV Approved Aviation Ratings 1941 and 1945[241]

7 Dec 1941	14 September 1945
Aviation Machinist's Mate, Aviation Metalsmith Aviation Ordnanceman Aerographer Photographer	Aviation Machinist's Mate, Aviation Machinist's Mate C (Carburetor Mechanic) Aviation Machinist's Mate F (Flight Mechanic) Aviation Machinist's Mate H (Hydraulic Mechanic) Aviation Machinist's Mate I (Instrument Mechanic) Aviation Machinist's Mate P (Propeller Mechanic) Aviation Machinist's Mate T (Gas Turbines) Aviation Electrician's Mate Aviation Radioman Aviation Radio Technician Aviation Metalsmith Aviation Ordnanceman

[240] Buchanan, *The Navy's Air War*, 322–23.
[241] Bureau of Naval Personnel, "Enlisted Personnel Distribution," in *United States Naval Administration in World War II* (Washington D.C.: U.S. Government Printing Office, 1959), Appendix A, B.

	Aviation Fire Controlman Aviation Ordnanceman T (Turret Mechanic) Airship Rigger Aerographer's Mate Photographer's Mate Torpedoman's Mate V (Aviation) Painter V (Aviation) Storekeeper V (Aviation) Aviation Boatswain's Mate AG (Arresting Gear) Aviation Boatswain's Mate CP (Catapult) Aviation Boatswain's Mate GA (Gasoline Stowage) Aviation Boatswain's Mate PH (Plane Handling)

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BuAer and NATTC also took the lead in establishing opportunities for women in the navy. The aviation side of Women Accepted for Volunteer Emergency Service (WAVES) was especially successful in supplementing the navy's technical aviation labor requirements. The WAVES Program was authorized on 30 July 1942. When the first Director of the WAVES Program, Lieutenant Commander Mildred McAfee, reported to the Chief of BuAer in September to discuss the role of WAVES in BuAer, Towers, ever the proponent of having women in active military service, bellowed, "Where have you been all this time? We've been clamoring for these WAVES and nobody's ever listened to us …." BuAer had requested 20,326 WAVES at the outset of the program. This was twice the number BuPers had requested and the largest amount of any Navy Bureau. BuAer's plans for utilizing WAVES eventually encompassed over 12,000 WAVE officers and 75,000 enlisted women. Initially, WAVES' duties involved clerical and administrative work, but soon the demands for skilled aviation technicians overcame

reluctance to abrogate the established boundaries of gendered discrimination in work roles.[242]

Gladys Marsheck Echols of Dundalk, Maryland was a member of the first class of enlisted WAVES to complete Aviation Machinists' Mate A School in Memphis, Tennessee at the end of 1942. Echols was a member of the first class of WAVES to attend aviation technical training. She recalled being given an option to attend Yeoman School and learn the administrative trade that would place her in the office environment for the duration of the war or attend a technical school. She had stenography skills from her previous job working for a local lawyer, but grew up the daughter of a filling station/repair shop owner in East Baltimore. She knew her way around a mechanic's shop and how to handle tools because of growing up around her father's automotive repair business. According to Echols recollection, this was the primary reason she was selected for Aviation Machinists' Mate rating upon graduation from boot camp. The other reason was the fact that she was tired of all the typing she had done at her stenographer's job and wanted to do something different in the navy than what she had done as civilian.[243]

The Aviation Machinist's Mate A School for WAVES was six months from start to finish, the same length for the male students. She was one of 144 WAVES assigned to Naval Training Center Memphis, which was a relatively small, but significant number considering women had never had such an opportunity before. Even in the midst of the

[242] Captain Mildred McAffee Horton Oral Transcript, 1969, U.S. Naval Institute, Annapolis, MD. As referenced in Reynolds, *Admiral John H. Towers: The Struggle for Naval Air Supremacy*, 381.
[243] Gladys Marsheck Echols, Veteran's History Project, Oral Histories from Dundalk, Maryland, Transcribed, November 14, 1988, 7–8.

other 14,000 male students undergoing "A" school training at the time, Echols memories of the training were positive. When asked about her experience she recounted,

> It was terrific! There were 144 women and 14,000 men … So there was no wanting for dates. But the school was very, very interesting. We learned mechanical drawing. We learned how to sew the fabrics of airplane repair, the covering of the planes the pilots trained in. We learned all about carburetors and starters and timing and all kinds of mechanical things … we went into the shops with the men at the different bases, and some went on the flight lines to the planes going in the morning… When you were through, you would be the equivalent of a garage mechanic today.[244]

After graduating in June 1943, Echols was assigned to the fabric shop of an Assembly and Repair facility in Pasco, Washington. Here, she and other WAVES worked on aircraft fabric (or skin) to cover the airframes of Stearman airplanes used for primary pilot flight training. Her experience was one of gender-based integration, recalling that she and the other WAVES were routinely trained and placed into the same work spaces as their male counterparts.[245] However, traditional views of gender roles still governed behavior.

When she first showed up at the A&R facility in Pasco, the fully trained WAVES were assigned to the fabric shop because there was an expectation that they had more experience sewing than the male technicians, as the domestic stereotype of women was still alive in 1942.[246] But, this was not a demotion or an assignment unworthy of their

[244] Echols, 8.
[245] Echols, 9.
[246] Echols, 9.

training received in Memphis. Sewing aircraft fabric was a routine job for AMMs and had been done by male technicians since naval aviation began. However, according to Echols, there were traces of old attitudes about gender roles that were evident while working in the A&R facility. Whenever one of the male sailors tore or split his trousers, he would place them in the "to do" pile for the WAVES to sew. Echols and the other women accepted this as part of the job and there were no bad feelings between the men and women in the shop. Echols specifically recalled that while at Pasco, the WAVES were treated with more respect there than any of her previous assignments. "We were accepted there better than any place we'd been, by the men. They were just great to us at Pasco."[247]

Eventually Echols and the other WAVES moved on to different jobs within their ratings, as well as being transferred to other bases throughout the country. Her next assignment was to NAS Olathe, Kansas where she was placed into the A&R shop again. But here she began to work on the assembly and disassembly of aircraft engines as part of the overhaul process. She finished out her career with the rank of Aviation Machinist's Mate Second Class (AMM 2/c) stationed at NAS Bunker Hill, Indiana.[248] There, she was assigned to the flight line a mechanic whose daily duties included starting the airplanes in the morning and conducting post-flight inspections and maintenance at the end of the day. As the war drew to a close, she was discharged in October 1945, a few days short of three years active duty.[249]

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[247] Echols, 11.

[248] The title of "Petty Officer" is usually accompanied by either 1st, 2nd, or 3rd class as an identifier of rank. In US naval terminology, one's rating may be substituted both formally and informally for the title of petty officer. i.e. Petty Officer Second Class (PO 2/c) is interchangeable with Aviation Machinist's Mate Second Class (AMM 2/c).

[249] Echols, Veteran's History Project, Oral Histories from Dundalk, Maryland, 17,28.

The WAVES experience varied from woman to woman and rating to rating, but overall it was a telling example of the progressive thinking that Towers and other naval aviation leaders embraced during World War II. Contrary to the well-known story of "Rosie the Riveter," where women worked on the production line of aircraft and ship building companies, U.S. Navy WAVES had the opportunity to contribute to the war effort in a uniformed capacity. Working on the flight line, A&R facilities, or in squadron maintenance spaces, female technicians applied their skills alongside their male counterparts. BuAer's willingness to place women into NATTC's schools and then into shore-based operational commands within the United States is a noteworthy chapter in the latter part of the first wave of feminism.

U.S. naval aviation technical training grew from a few part-time assembly and repair facilities that conducted technical instruction casually to a small number of men, to a training colossus that involved hundreds of instructors and hundreds of thousands of students. NATTC built upon the model BuAer had begun in 1939-40 with Murray and Wheelock's initiatives in personnel planning and technical training. In the mid 1930s there were no such thing as aviation Class A, B, or C schools. By January 1942, there were twelve Class A, six Class B, and ten Class C technical aviation schools operating throughout the country.[250] Shortly thereafter, each one of those schools was categorized into four categories of educational activities, amounting to over thirty total "class" schools. The impact of what NATTC had done in terms of the navy's technical aviation training was tremendous. By the summer of 1945, NATTC had trained over 300,000 aviation technicians among its sixty odd schools that were in existence at one point or

[250] Wheelock, "Lecture on Duties of Divisions in the Bureau of Aeronautics, Navy Department."

another since 1942.[251] The notion that the training would naturally occur while operating in a routine, operational environment through hands-on, real-time experience had been forgotten. While most of navy and Congressional leadership were looking at the materiel face of the war in terms of aircraft and weapon technology, NATTC did not lose sight of the overall picture. What good was the latest technology if squadrons could not keep airplanes airborne? What difference would thousands of new pilots make with no airplanes to fly because they were inoperable? The NATTC technical graduates would soon become as important to the war effort in the Pacific as the Grumman fighters, torpedo, and bombs, which they serviced.

[251] Headquarters, Naval Air Technical Training Command, *Technicians' War: A Picture Story of U.S. Naval Air Technical Training Command*, sec. Naval Air Technical Training Command.

Chapter 5: Specialization of Labor and Timing the Delivery

As the size of the U.S. Pacific Fleet's carrier force rapidly increased after 1942, maintenance of the high number of state-of-the-art carrier-based aircraft participating in combat operations compelled the U.S. Navy to transform its aviation technician labor force through specialization and division. Prior to the outbreak of hostilities, aircraft maintenance was a relatively simple affair, confined to naval facilities that were located on land and usually in the vicinity of a major Naval Air Station. Permanent, spacious structures provided ample work spaces for technicians. Fuel, lubricants, and spare parts were generally close at hand. It was common practice for pilots to work on their own airplanes along with a small crew of enlisted technicians from the squadron when it came to routine maintenance. For major repairs or comprehensive overhaul, aircraft were sent to dedicated Assembly and Repair Facilities such as the Naval Aircraft Factory in Philadelphia.[252] Aircraft maintenance in the peacetime navy was largely an unhurried activity that drew little attention from anyone outside of the pilots and technicians themselves. During the 1930s, flight operations were relatively limited, as the navy maintained no more than six aircraft carriers at one time engaged in undemanding deployments. Thus, the navy did not have to face a myriad of challenges posed by having to support a large and actively engaged carrier force with a commensurately robust aircraft maintenance capability while engaged in a protracted war. Historical arguments that place technology, tactics, or materiel as the substantive keys to Allied victory are not necessarily wrong, but other things mattered a great deal as well. A critical examination

[252] Buchanan, *The Navy's Air War*, 354.

of pre-war and wartime naval aircraft maintenance herein confirms that until the navy grew the size of its skilled labor force to the match the size of its carrier fleet and supporting units at sea and ashore, the operational viability of the carrier force as the navy's primary offensive instrument was open to considerable doubt.

As late as the latter half of the 1930s, U.S. Navy carrier aviation was a relatively novel concept. It had been a part of the navy for only a decade and a half. Until 1935, aircraft maintenance aboard carriers did not make large demands on the navy's resources. This was because the number of aircraft carriers in service was quite small compared to what it would become midway through World War II. The *Langley* had been consigned to mostly experimental or research and development operations by the middle of the decade. Thus, the U.S. fleet possessed only three battleworthy carriers that only operated between 200 and 230 airplanes. The commissioning of five additional units between 1936 and 1941 added an additional capacity of 373 aircraft.[253] Although the number of aircraft operated by the navy more than doubled, the total carrier aircraft complement at the start of the Second World War only came to approximately 600. Peacetime deployment schedules did not require squadrons to put aircraft to sea for long periods under stressful, combat conditions. However, once the U.S. entered the war, the proliferation of naval aircraft was staggering. The following table (5-1) shows the strength of carrier-based aircraft based on aircraft carriers in commission over the course of the war. This table theoretically shows how many aircraft the U.S. could operate at any one time, separated by class of ship based on the number of aircraft carriers in service.

[253] Ship, Commissioning, Aircraft Complement: *Langley*, 1920; *Saratoga*, 1927, 78; *Lexington*, 1927, 78; *Ranger*, 1934, 76; *Yorktown*, 1937, 90; *Enterprise*, 1938, 90; *Wasp*, 1940, 100; *Long Island*, 1941, 21; *Hornet* 1941, 72. Source: Norman Freidman, *U.S. Aircraft Carriers*, (Naval Institute Press, Annapolis, MD, 1983)

Table 5-1: Aircraft Strength per Aircraft Carrier Class[254]

	12/31/41	12/31/42	12/31/43	12/31/44	October 1945
CV	570	330*	650	860	1,220
CVE	30	390	1,050	2,040	2,250
CVL	0	0	300	300	300
Total Carrier-based	600	620	2,000	3,200	3,500
Total (Carrier-based + Land Based	3,430	7,058	16,691	34,071	40,912

* Due to losses of *Hornet, Lexington, Wasp,* and *Yorktown* in 1942.

The more planes that the navy possessed, the more aircraft technicians it would need to support operations. Table 5-1 shows an approximate doubling of total naval aircraft each year (except for 1945). What is interesting is the significant increase of carrier-based airplanes in 1943. Was the navy intentional in withholding carrier aircraft from the fleet until it had the labor force in place to support flight operations? Another valid consideration was the number large of carriers under construction in 1942. Without new *Essex*-class to fight from, what good would a bunch of new airplanes be? Fortunately, many Reservists were activated in 1941-42, and carried much of the early workload. By

[254] Norman Polmar, *Aircraft Carriers: A History of Carrier Aviation and Its Influence on World Events* (Dulles, VA: Potomac Books, 2006), 273.

mid-1942, the number of trained aviation technicians was on a steady rise; inventories of aircraft and aircraft carriers soon followed.

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Aboard carriers, personnel were split between those accountable for attending to the ship's operations and those accountable for the daily air operations. The Air Department was responsible for the administration and control of all aviation-related duties, as well as supporting the facilities for maintenance and operation of aircraft. Storage and upkeep of all accessories, work spaces, and even berthing for aviation personnel were also part of its responsibilities. Trained aircraft technicians performed the day-to-day maintenance on the airplanes. The Air Department as a whole, integrated with non-flying squadron personnel to perform jobs such as loading ordnance, directing plane movements, manning the crash, salvage, and fire-fighting crews, plus fueling.[255] Once the group of squadrons—administratively known as an Air Group—embarked, the ship's company blended with squadron personnel to become a cohesive, unified unit. At its most basic level, the daily task of non-flying personnel was to ensure that airplanes launched per the daily flight schedule. Everyone worked to achieve this goal. Once an aircraft left the deck, it was the pilot's job to complete the mission. It was no secret that this was impossible to do without a properly maintained aircraft.

The larger carriers of the *Essex*-class were originally designed before the Pacific War. The keels of the first three *Essex*-class aircraft carriers (*Essex* (CV-9), *Yorktown* (CV-10), *Intrepid* (CV-11)), in fact, were laid before the attack on Pearl Harbor. These ships were designed with embarked Air Groups in mind, but the plans were based on

[255] William Halsey, "CV-The Carrier," *Flying and Popular Aviation*, January 1942, 120.

carrier aircraft flying in 1939, not 1943 or 1944 when most of the *Essex* class would become operational. Therefore, the number of aircraft on board U.S. carriers fluctuated from original plans throughout the War, beginning with an average of 90 in 1943, then 96 in 1944, and finally 102 in 1945. Changes in aircraft design, especially the adoption of folding wings, flight deck modifications, and how many spares aircraft were carried on board were responsible for these changes.[256] The available pool of pilots also increased each year, which made larger-sized air groups possible. The following table shows the change in dissemination of type aircraft per air group from pre-war through its end.

Table 5-2: Average *Essex* Class CV Air Group Compliment[257]

	1940[258]	1941-1943	1944	1945
VF (Fighter)	27	36	54	73
VSB (Scout Bomber)	37	36	24	15
VTB (Torpedo Bomber)	18	18	18	15
Total	82	90	96	103

The increased number in fighters and decreased quantity of scout bombers coincided with the phasing out the aging SBD *Dauntless* and the introduction of a newer, yet troublesome SB2C *Helldiver*. In addition, in the last years of the war, the navy modified its F6F *Hellcat* fighters to carry bombs and function as a multi-role fighter-bomber airplane. This alleviated the need to carry as many SB2Cs as had been anticipated. Many of the Curtiss SB2Cs were therefore replaced with newer models of Grumman's

[256] Friedman, *U.S. Aircraft Carriers*, 151–55.
[257] Friedman, *USS Yorktown (CV-10)*, 20.
[258] 1940 figures in Table 5-2 are from original *Essex* design.

F6F, simplifying both maintenance and supply aboard the carriers, but ultimately increased the number of airplanes operating from the carriers.[259]

The ratio of technician-per-plane in World War II changed very little since CDR Dubose suggested eight to ten when testifying before Congress in 1924.[260] The *Essex* was originally designed to deploy with 537 aviation enlisted personnel and 84 aircraft.[261] This was a drop from 601 enlisted aviation personnel on the *Hornet* (CV-8), even though it carried only 72 aircraft.[262] Over the course of the war, aviation technicians in *Essex*-class carriers averaged between five to seven enlisted men per embarked aircraft. In 1945, the newer *Lexington* (CV-16) reported 765 enlisted in the air department with 102 airplanes, a ratio of 7.5 to 1.[263] By comparison, the U.S. Army Air Corps required eight enlisted technicians per fighter and sixteen per light bomber within their squadrons. The average size of an army fighter squadron was 25 airplanes, 41 officers (pilots), and 210 enlisted mechanics. A light-bomber squadron of A-24 model airplanes consisted of 13 planes, 25 officer, and 211 enlisted men.[264] In terms of large unit size, if multiple army squadrons were combined in a similar fashion to the make-up of a 102-plane navy air group (3 fighter squadrons, 2 light bomber), the total number of army technicians would equal 1,052 men, three to four hundred more than the navy had available. Even older

[259] Robert Guttman, "Curtiss SB2C Helldiver: The Last Dive Bomber," Aviation History, July 2000, 3, https://www.historynet.com/curtiss-sb2c-helldiver-the-last-dive-bomber.htm/3 accessed January 25, 2019.
[260] op. cit., 19.
[261] Bureau of Ships, "U.S.S. Essex-Design Of," September 10, 1940, Carriers Collection, Box 7, NHHC.
[262] Bureau of Ships.
[263] "History of USS Lexington (CV-16) from 17 February 1943 through 31 March 1945," June 11, 1945, 47, RG 38 "World War II War Diaries," NARA II, https://www.fold3.com/image/302074535. accessed 19 February 2019.
[264] Wesley Frank Craven and James Lea Cate, eds., *The Army Air Forces in World War II*, vol. 1, Plans and Early Operations, January 1939 to August 1942 (Chicago, IL: The University of Chicago Press, 1955), 747–48.

carriers such as *Hornet* had a smaller ratio, approximately eight technicians per aircraft, than the army.[265]

On average, approximately one-third of the enlisted personnel aboard aircraft carriers were on board to support air operations. Managing a labor force of this size, while navigating the challenges of a relatively new work environment for most of the men, was a daunting prospect. Based on the experiences of the interwar carrier navy, the most efficient way to accomplish this task was through a division of labor.

Since the *Lexington's* earliest days, aircraft carriers divided its personnel into two general categories: ship operations and aviation operations. Those who were assigned to ship's company were responsible for the traditional naval operations of the vessel, its integrated weaponry, navigation, daily operations, meals, etc. Their duties also involved maintenance of the flight deck, arresting gear and catapults, and physical condition of the hangar spaces. Men assigned to the air department were only responsible for the operation and maintenance of the aircraft including the associated support equipment and shops.

The air department was an independent unit within the ship, sub-divided into five smaller units: Flight Deck Division (V-1), Engineering-Maintenance Division (V-2), Combat Information and Control Division(V-3), Ordnance and Servicing Division(V-4), and the Air Group (V-5), which consisted of officer and enlisted aircrew (pilots, navigators, bombardiers, radio operators, and gunners). V-1, V-2, and V-4 personnel

[265] The ratios herein are not exact numbers. Some of the technicians worked in the different aviation shops and some were administrative in nature. But for general comparison, the numbers are based solely on documented personnel. See Friedman, *U.S. Aircraft Carriers*, Appendix E.

worked on the flight deck and in the hangar with the aircraft.[266] The enlisted men of the V-3 division did not take part in the maintenance of aircraft, as their jobs were associated primarily with flight operations, ship-aircraft communications, and radar. Neither was the V-5 division a part of the maintenance team *per se*, but on occasion would assist air department technicians as needed. Additionally, the sailors in V-1 division were not considered aviation maintenance technicians either. Many had completed their training *via* the NATTC schools, but their job was not primarily about aircraft maintenance or repair. Some of their duties, for instance, included physically moving or "spotting" airplanes on the deck, refueling, operating tractors that moved the planes around the deck, and maintenance of the aircraft arresting gear.[267]

The V-1 flight deck sailors were identified by the color of their jerseys. Each crewmember wore a different color shirt that identified his job on the flight deck. Flight deck plane handlers wore blue and positioned the airplanes for the day's flight schedule. The plane directors, who supervised the handers, wore yellow jerseys. Sailors who were responsible for removing and replacing wheel chocks when launching and parking aircraft, respectively, wore purple. The tow tractor drivers assigned to moving aircraft were also outfitted in yellow. Gasoline crews responsible for refueling did not wear a specific color jersey, but only donned red helmets with their standard dungaree uniforms. The crews or "hook-men" that operated and maintained the arresting gear were identified by green helmets and green jerseys. Firemen stood by with carbon dioxide extinguishers

[266] Blaine Stubblefield, "Carrier Aircraft Maintenance Is Really Tough," *Aviation*, June 1945, 107; Blaine Stubblefield, "It's No Child's Play: Arming and Fueling Carrier Planes," *Aviation*, August 1945, 111. By the end of the war, the division labels had changed slightly, placing Ordnance and Servicing under the direction of V-1, renaming V-3 Operations, and making V-4 the Administration Division.
[267] "Aviation Maintenance," 72.

wearing red helmets and red jerseys. The Flight Deck Officer, who was responsible for the entire operation, always wore a white helmet and white jersey. The plane captain, often a junior AMM or AM fresh out of A school, wore a brown shirt and brown helmet.[268]

A plane captain was assigned individually to each plane aboard the ship. He was personally responsible for his airplane's daily servicing and care. The plane captain usually had his name and hometown painted on the nose of the aircraft to foster ownership and pride in his work.[269] His duties typically included cleaning or washing the plane, tying down aircraft properly, inspecting tires and landing gear, ensuring the airplane was properly refueled, checking and servicing engine and hydraulic oil levels, and conducting preflight inspections. When an aircraft needed repair that required an elevator ride down to the hangar, its plane captain worked alongside the hangar deck technicians to schedule routine repair or remedy of a more serious nature.[270]

The Flight Deck Division performed work that was essential to daily combat operations. The main offensive and defensive capabilities of an aircraft carrier depended upon its efficiency. In order get the airplane to the deck and ready to launch, all the mechanical systems of the airplane had to be in working order before it was even assigned to the flight schedule. This is where the skilled technicians of the Engineering Department were most valuable.

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[268] "Aviation Maintenance," 73.
[269] The tradition of painting the name and hometown of the plane captain on naval aircraft is still practiced today.
[270] "Aviation Maintenance," 74.

The Engineering Division (V-2) on the earliest *Essex*-class aircraft carriers, such as *Essex* (CV-9), consisted of between 180-200 men.[271] The men were responsible for the maintenance of every airplane aboard the ship. Sailors of the V-2 division were usually graduates of the aviation trade schools, or after 1942, the NATTC schools. It was typical that a routine inspection on each aircraft was performed after thirty hours of flight time. BuAer's regulatory thirty, sixty, ninety, or one hundred and twenty flight hour inspections on each carrier aircraft were the responsibility of these technicians. This type of inspection involved checking engine function, fluid levels, and general condition of the airplane structure. After each thirty hours of flight time, the inspections became more rigorous and lengthier, until the aircraft eventually reached its manufacturer's recommended overhaul period. On average, the normal overhaul period for naval aircraft was every eighteen months in peacetime.[272] Depending on the tempo of flight operations, the time between overhauls would shorten dramatically once the air war in the Pacific began.

The Aviation Engineering Division onboard an aircraft carrier was divided into three subdivisions: Engineering (V-2E), Electronics (V-2R), and Shops (V-2S). With the rapid increases in carrier numbers and the size of carrier air groups, however, came the need for further specialization within the navy's aviation workforce. Therefore, each division was divided even further by type of aircraft. Technicians were assigned to small technical units that were qualified to perform maintenance on only one specific of aircraft: fighters, dive bombers and scouts, or torpedo planes. [273] For example, an AMM

[271] "Aviation Maintenance," 76.
[272] Schaeffer, 135.
[273] "Aviation Maintenance," 75.

in the V2-E division might only be qualified to work on fighters, but not dive-bombers. Therefore, each type of aircraft had a dedicated maintenance team for the duration of deployment. This specialization of labor represented a remarkable change for naval aviation maintenance procedures

Within the V-2E division, fighter aircraft (VF) technicians comprised the greatest number of maintenance "check" crews, ten in number. Bomber/scout aircraft (VB/VSB) had six and torpedo aircraft (VT) required four.[274] The fighter crews were supervised by a lieutenant, junior grade (LTjg), who had experience as either a pilot or had aviation maintenance training *via* the aviation technical trade schools and/or a Carrier Aircraft Service Unit (CASU). His enlisted counterpart was usually a senior enlisted such as an Aviation Machinist's Mate, Chief Petty Officer (AMMC). The typical check crews normally contained five additional technicians, but the minimum requirement being (1) AMM 1/c, (1) AMM 2/c, (1) AMM 3/c or an "undesignated" Seaman (SN). The other two members could vary in rank based on what was available to the Air Group at the time. Additionally, all the work completed by the check crews was inspected by two to four AMMCs who were split into day and night shifts. The airplane was not considered "safe-for-flight" after their final inspection and all associated documentation was submitted to the Maintenance Control Officer. Only then would the airplane be available for the following day's flight schedule.[275]

The check crews had to have a supporting network of tools, materials, and specialty technicians to assist when parts needed to be replaced or repaired. This is

[274] Check crew numbers are based on late 1943-early 1944 data. As numbers of aircraft varied throughout the war, the quantity and division of check crews varied as well. See Table 5-1
[275] "Aviation Maintenance," 75.

where the V-2S Division came into play. The aircraft carrier was designed to provide ample maintenance and repair at sea for aircraft. The number of facilities onboard was numerous. A metal shop employed forty-two artisans and the hydraulic shop had twelve sailors assigned to it. There were other shops, smaller in size and more specialized: a paint shop was manned by four sailors while the sparkplug overhaul, propeller, and oxygen transfer shops utilized two sailors each. There were also machine, electrical, radio, radar, and parachute shops. Each required a few enlisted sailors on day and night shifts to support the embarked Air Group. When repairs, fabrication, or servicing were more complicated than what could be completed quickly while the airplane was in the hangar or up on the flight deck, the check crew would bring the part or parts to the shops for repair or replacement. The V-2S division also supported flight operations by maintaining the shops for the arresting gear, the catapult machinery, and the torpedoes. All of the technicians aboard were trained on their respective systems before reporting aboard the ship, ensuring the aircraft carrier's labor force continued to become more and more specialized.[276]

Aircraft ordnance and its associated systems, plus aircraft fueling was handled by the V-4, Ordnance and Servicing Division. V-4 typically had 100-110 technicians onboard at any time. These maintainers were responsible for everything from forward-firing fixed aircraft guns and rockets to torpedoes and refueling airplanes on the flight deck. A lieutenant was in charge, with a lieutenant junior grade assisting. Two chief petty officers rounded out the management. One chief was in charge of all aircraft gunnery and the other was responsible for the aircraft-launched torpedoes and bombs.[277]

[276] "Aviation Maintenance," 75–76.
[277] "Aviation Maintenance," 78.

The relationship between a plane captain and his aircraft was mirrored by the V-4 division in terms of its ordnance technicians and aircraft weapons. On an *Essex*-class aircraft carrier, a single technician was assigned to each fighter on board. Thus, the number of V-4 technicians utilized in this fashion varied from an average of thirty during the first two years of the war to upwards of seventy by the end. These numbers were commensurate with the adjustments in an air group's compliment of aircraft during the course of the war.[278] The maintainer was responsible for all gun systems, ammunition, and rockets, if so equipped. Loading and unloading of ammunition, as well as servicing and repair of the gun and rocket launchers, all fell under his responsibility. Airplanes that carried a crew-served weapon (a manually operated rear gun), such as the TBM *Avenger*, often utilized the same technician who maintained the weapon as the aircrew gunner.[279]

The technicians who were assigned to the three bomb loading crews onboard were responsible for loading and unloading all air-launched torpedoes and bombs. The torpedoes themselves required considerable maintenance in order to keep them in a constant state of readiness. The internal guidance and fusing of an air-launched torpedo was a complicated feat of engineering and mechanics. The weapon was not something that could be quickly loaded onto an airplane and taken aloft. The torpedo shops employed weapons experts to ensure the detonator, propulsion, and guidance systems were properly set before uploading the torpedoes onto aircraft.

Aircraft maintenance onboard the smaller escort and light carriers (CVE and CVL) was similar, although there were a few differences.[280] The four major aviation

[278] See Table 5-1.
[279] "Aviation Maintenance," 78.
[280] The overwhelming majority of smaller carriers were of the *Casablanca*-class. Fifty (50) were built by the Kaiser Company between November 1942 and July 1944. The other non-*Essex*-class smaller U.S.

departments had the same identifiers as on the *Essex*-class, but fueling was managed by the V-2 division (which was identified as Hangar Operations instead of Engineering) rather than V-4. The most significant material difference, however, was the physical footprint of the air department and its aircraft. Escort carriers nominally operated approximately twenty-two aircraft, split between fighters and torpedo bombers (VF and VT). Scout bombers were not a regular component of the escort carrier.[281]

The division of labor onboard the CVE was also different than on the larger *Yorktown* and *Esse*x-class carriers. Most likely due to the smaller number of aircraft, technicians were not divided by type of aircraft as they were on the CV. This meant that on a CVE, maintainers were employed on both VF and VT aircraft simultaneously. For example, an Aviation Machinist Mate on a CVE had to be qualified to work on both F6F *Hellcats* and TBM *Avengers*.

The personnel distribution of the V-2 division also varied, but a specialized labor force was still the standard. There were four check crews comprised of three-man teams, each supervised by a chief petty officer. The check crews were typically divided into three "day" crews and one "night" crew. Six specialists were available to assist the maintenance crews on a round-the-clock basis. These technicians received special training in aircraft instruments, propellers, carburetors, hydraulics, landing gear, and empennage (tail section) and were designated as such in their ratings. For example, an Aviation Machinists' Mate Hydraulics Specialist First Class would be rated AMMH 1/C. A chief petty officer would supervise the entire group of AMM specialists.[282]

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carriers were the *Bogue* (10), *Sangamon* (4), *Independence* (9) , *Commencement Bay* (4) and *Avenger* (1) - classes. See Friedman, *United States Aircraft Carriers*, (USNI, Annapolis, MD), 1983.

[281] "Aviation Maintenance," 80.

[282] "Aviation Maintenance," 80.

Within the hangar spaces, the V-2 division had its own network of shops, although much smaller than that on the CV. The electronics shop was manned by three Aviation Radar Technicians (ART), typically a single ART 1/c and two ART 2/c. The electronics shop supported aircraft radar and radio systems and was also responsible for the rest of the aircraft electrical systems. A first-class Aviation Electronics Mate (AEM 1/c) worked with two to three more junior AEMs. The largest shop was metal repair. It was supervised by an Aviation Metalsmith Chief Petty Officer (AMC) and employed eleven other AMs. As was common with all aviation ships, a parachute loft also existed, but it only contained two Parachute Riggers (PR). The CVE's V-2 division averaged about half as many technicians, between 100-120, compared to the larger 180-200-man V-2 division on the CV. However, plane captains and fueling personnel were lumped into V-2 on the smaller carriers, thus bringing the number of assigned personnel closer to 140.[283]

V-4, the Ordnance Division, was divided into three smaller sections, similar to the CV. There were four crews for bomb and torpedo loading, each comprised of four Aviation Ordnancemen. Each crew was responsible for approximately three of the dozen or so VT aircraft onboard. The gun and rocket systems on the fighters were also maintained by a four-man crew. Each crew was assigned approximately three aircraft, the same as the torpedo and bomb crews. The third part of the Ordnance Division was comprised of the Assembly and Hoist Detail. This group was further divided into a nine-man team of bomb handlers and vane-assemblies team. There was also a four-man team which was responsible for torpedo and bomb fusing operations. The entire Ordnance

[283] "Aviation Maintenance," 80–81.

Division on the CVE was approximately one-half the size of the CV's V-4 Division, averaging between forty and fifty aviation ordnance technicians per ship.[284]

Daily operations for the maintenance crews aboard carriers were similar whether it was a CV or CVE. Each night, aircraft had to be positioned or "spotted" for the next day's flight schedule. The V-2 division compiled a daily "availability" report that provided planners an idea of how many and what types of aircraft would be available to fly the following day. The nightly report would list the total number of planes that were flyable or in a ready status. This term was shortened to "up." Those planes that were undergoing repair were reported as "down for repair" or simply "down." An estimated time and date of repair completion was added to these aircraft statuses. If an aircraft was approaching a BuAer-mandated hourly inspection, such as a thirty or sixty-hour inspection, that information was also provided for planning purposes.[285] The goal was always 100% availability, but this was rarely achieved. Usually, it ranged from 80% to 90%, only dipping lower after periods of combat when aircraft were lost or severely damaged by enemy fire.[286]

Carrier aviation technicians faced significantly more challenges compared to their land-based counterparts. They were thus forced to adapt to complex work conditions that did not exist for a land-based airplane mechanic. One such issue was the lack of space in which to work.[287] In the hangar, aircraft were positioned within a few feet, and sometimes just inches from each other, often with their wings folded in order to make room for more. There was little room for technicians to maneuver around parked

[284] "Aviation Maintenance," 80–81.
[285] "Aviation Maintenance," 82.
[286] Stubblefield, "Carrier Aircraft Maintenance Is Really Tough," 106.
[287] Stubblefield, 108.

airplanes. Striking one's head on the side of an airplane or propeller was a common hazard. Work platforms had to be placed with great care and then tied down when in use so as not to hit another airplane when the ship rolled due to heavy seas or maneuvering. Tools had to be accounted for at all times and could not be left lying around. A screwdriver that rolled behind the flight controls could be catastrophic to an aircraft in flight. The constant pitch and roll of the ship required a diligence and attention to detail in how work was accomplished, what tools were used, and where they were placed when not in use. The risk of something such as a replacement engine falling from of its work stand as the ship rolled heavily was very real. For the land-based aircraft technician, the stability of their workspace alleviated many of these concerns.[288]

While airplanes were in the hangar, their wings were usually folded in order to save space. Folded wings allowed more airplanes to be stored in the hangar, but it brought with it its own problems that were not easily remedied. For example, as late as January 1944, maintenance crews aboard the *Saratoga* were requesting a work stand be designed and approved by BuAer that would could be hung on carrier aircraft while its wings were folded, giving technicians a safe and stable platform that would save time and labor. Aircraft like F6Fs and TBFs employed wing guns that needed servicing after each flight.[289] The intricacies of a carrier hangar deck called for more innovative measures than many aviation engineers had foreseen as the war progressed.

Trying to maneuver so many aircraft in such cramped spaces often resulted in one airplane striking another while under tow. These "hangar crashes" were usually minor,

[288] "Aviation Maintenance," 76.
[289] "Saratoga Seeks New Stand," *Naval Aviation News*, January 1, 1944, 28.

but they required the attention of artisans and inspectors, even in cases of minor repair.[290] There was less chance of such damage occurring at shore facilities. Additionally, the constant folding and unfolding of an aircraft's wings in order to make space in the hangar or flight deck put additional stress on aircraft mechanical and hydraulic systems. Loose fittings and weak hydraulic hose connections were also a common troubleshooting item for check crews as they discovered leaks and malfunctions.[291]

Other "pilot-induced" damage that was common in carrier aviation were tire blow-outs and "prop strikes." Carrier landings in the 1930s and 40s were conducted more as a "controlled crash" than a traditional runway landing. Once his airplane crossed the deck edge, the carrier pilot immediately pulled the throttles back to idle, effectively stalling the engine so the airplane would fall to the flight deck, fifteen to twenty feet below, often causing a blown tire. The goal was to catch the steel hook hanging from the tail of airplane onto one of the wires horizontally traversing the flight deck and arrest forward momentum before continuing over the bow of the ship into the sea below. If the pilot applied brake pressure too abruptly at this point, it would often cause a "nose over," damaging the aircraft's propeller. Only the front landing gear had brake systems, and most aircraft were heaviest forward of the cockpit where the engine was located. Replacement propellers were one of the few items that are actually assembled on the ship. Tires and many other aircraft parts came fully assembled from the manufacturer and were ready for immediate installation.[292]

[290] Stubblefield, "Carrier Aircraft Maintenance Is Really Tough," 107.
[291] Ibid.
[292] Stubblefield, "Carrier Aircraft Maintenance Is Really Tough," 107.

Salt water spray and vapor wreaked havoc on aircraft metals. Corrosion compromised the structural integrity of air frames and the reliability of active mechanical systems such as engines' landing gear, and armament. Salt build-up on the covering of airplanes roughened what should have been smooth exterior surfaces, which induced aerodynamic drag that could reduce an airplane's maximum speed by as much as ten miles per hour (10 mph). To combat the salt, the maintenance teams tried their best to regularly rinse down the aircraft, but fresh water was limited due to the other requirements like bathing, drinking, laundry, cooking, and boiler feeding. Therefore, each part of the airplane that was easily accessible was regularly coated with a corrosion inhibiting oil. This helped somewhat, but it was labor intensive and only provided partial protection from the salt water elements. After aircraft design transitioned from wooden frames and cloth skin in the 1920s to all metal in the 1940s, the navy could do little more than mitigate the constant onslaught of salt water corrosion on its carrier aircraft.[293]

Corrosion on spare parts was also a major concern for aviation mechanics. BuAer took great care in preserving spare parts while in transit or storage aboard the ship. Four preventative measures were considered standard procedures when spare engines and other parts were shipped to and stored aboard carriers. If the part was paintable, a corrosion-resistant paint or enamel was applied. Second, any extraneous material was removed from the parts to allow a preservative coat of oil or grease to be applied to the item itself. The third step consisted of applying a petroleum-based preservative on everything. Finally, the spare parts were wrapped in bags or other air-tight containers to keep humidity low and moisture out. Dehydrating agents such as silica gel were placed

[293] Stubblefield, 108.

inside containers or plastic film bags were used to keep the humidity at minimal levels. Even the type of paper used to wrap certain parts was considered in relation to its corrosion inducing properties. Papers containing acids were purposefully avoided since the chemical reaction--if the paper should become damp--would corrode the metal it was supposed to be protecting. Not all of these measures were exclusive to carrier aviation. Land-based units faced similar humidity and environmental concerns in the Pacific, however, the prevalence of salt water spray on a ship demanded a greater emphasis on corrosion prevention than the navy or army had to worry about in land-based aviation units.[294]

The majority of aircraft maintenance was performed overnight since throughout most of the war, combat missions were flown during daylight hours. After the pilots landed the maintenance crews took over. Aircraft were placed on elevators and lowered to the hangar decks below where they were inspected, repaired, and readied for the next day's missions. With only a limited number of aircraft onboard, naval aircraft technicians were always under a time constraint to accomplish their jobs expeditiously. If unable to complete the required maintenance overnight, the following day's missions would be compromised. The carrier technician's daily routine did not consider overtime, union contracts, or mandatory breaks. They worked until the job was complete, or they were relieved by someone else to perform what needed to be done.[295]

Most of the maintenance performed onboard aircraft carriers constituted what would eventually be labeled "Class D" maintenance. Class D mainly consisted of engine

[294] "Aircraft Corrosion: BUAER Develops Preservation Methods for Planes and Parts," *Naval Aviation News*, May 1, 1944, 1–2.
[295] "Aviation Maintenance," 77.

changes and the installation of components. The navy had three other classes of maintenance that did not fall under the responsibility of the V-2 division. Class A was major overhaul work on aircraft and engines; Class B was accessory and minor engine overhauls; and Class C constituted minor structural repairs and engine installation. If a carrier airplane required any unplanned major maintenance or repair while at sea, there was a very real chance that aircraft would be pushed over the side of the ship, according to accounts from maintenance officers at the time. During the latter half of the War, deck space was at a premium and replacement aircraft were plentiful. Repairs were done, but it was usually in conjunction with the installation of new parts. The carrier maintenance teams preferred to install new parts rather than fix broken ones if the parts were of significant size or cost. Even though the labor was very specialized on the carrier, the resources for lengthy, intricate repairs on aircraft were not practical.[296]

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During the interwar years, the *Lexington*-class carriers were designed to operate with one particular air group and its associated squadrons. These squadrons were organized into a self-sufficient unit, complete with maintenance capabilities. The air group was assigned to a specific carrier and embarked its squadrons, as needed. The small numbers of carrier aviation units, along with the minimal operational requirements that existed in the 1930s, did not require a permanent footprint of technicians and their associated materiel onboard the carrier unless the air group was embarked. Therefore, every time a squadron embarked or disembarked, a massive undertaking was required to

[296] Stubblefield, "Carrier Aircraft Maintenance Is Really Tough," 106.

load or unload all the support equipment, tools. administrative and maintenance personnel. [297]

Once war with Japan began, the time and labor required to transfer the maintenance divisions on and off the ship hampered the readiness of both the air group and the carrier. Carrier pilots were required to maintain their training even when the ship was in port for extended periods. Thus, the air group would fly their aircraft off the carrier and onto a naval air station when the ship was in homeport for long periods. Aircraft carriers also had to maintain the ability to deploy for combat operations on short notice. The time and cost of embarking and reembarking the air group's maintenance department was prohibitive. Due to the likely urgency off operational demands, the massive numbers of carriers and air groups that would eventually fight the war, and the cost of moving hundreds of men and supplies on and off made the existing procedure impractical.[298]

The navy had to change its carrier aircraft maintenance practices. Thus, the Carrier Aircraft Service Division (CASD) was established and became a permanent fixture on aircraft carriers whether an air group was embarked or not. It soon shortened its name to the Air Department.[299] The technicians assigned were aviation rated technicians, but were considered part of the ship's company. This explains why when researching squadron personnel rosters from air groups during the War, only the pilots and aircrew are listed.[300]

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[297] Stern, *The Lexington Class Carriers*, 116.
[298] "CASU Training Manual of the ACORN Assembly and Training Detachment" (Navy Department, February 1945), 1, WWII Aviation Training, Box 64, NHHC; "CASU: Carrier Aircraft Service Unit," *Naval Aviation News*, September 1, 1944, 13.
[299] Stern, *The Lexington Class Carriers*, 116.
[300] Robert Olds, *Helldiver Squadron: The Story of Carrier Bombing Squadron 17 with Task Force 58* (New York: Dodd, Mead & Company, 1944).

Once the "V" divisions became a permanent fixture on the CV, there had to be a unit ashore to maintain the aircraft when they left the carrier to operate from island or shore bases. This unit was designated a Carrier Aircraft Service Unit (CASU). Dozens of CASUs were established throughout the South Pacific Islands for the duration of the war, as well on U.S. coastal bases including Pearl Harbor. The primary job of the CASU was to support the carrier squadron by way of maintenance when its mission brought the aircrew and planes ashore for extended periods. Forward deployed CASUs took the place of carrier maintenance departments on shore where well-equipped naval air stations did not exist. The CASUs were mobile units that could be quickly stood-up in one area and then quickly transferred to another as ground forces secured small islands across the Pacific. There were nearly seventy CASUs in commission throughout the Pacific during the Second World War.[301]

The CASU averaged 17 officers and 516 enlisted men, but it varied in size depending on location. Some of these units could be as large as 1,500 enlisted with 89 officers—depending on the number of aircraft they were assigned to support at once: 45, 90, 180, 270, or 360. In addition, the CASUs were self-contained units. A CASU had maintenance, medical, welfare, ordnance, supply, and other administrative personnel assigned to it. Its primary task was to maintain and repair carrier aircraft, but it was not meant to, nor equipped to complete major overhauls. A&R facilities still handled the majority of Class A, B, and C maintenance.[302]

CASUs could also act as a forward staging area for replacement parts, aircraft, and squadron personnel rotating into the combat zones. On occasion, it also took on the

[301] "CASU: Carrier Aircraft Service Unit," 13.
[302] "CASU: Carrier Aircraft Service Unit," 14–15.

task of technical schooling for sailors who did not receive any or all of the NATTC training before being transferred to forward operating areas. The CASU would often have a ground school set up to train new recruits how to work on the three types of carrier aircraft (fighter, bomber, torpedo) in lieu of what they would have learned at an NATTC technical school. Many times, they would develop their own training courses designed to sharpen or refresh a technician's skillset.[303] CASUs were wartime-only units that were designed specifically to support the carrier war in the Pacific.

As the strategic picture of the war changed, so did the mission of a CASU. In late 1944 operations throughout the Pacific in late 1944 required more than just support from the carrier air groups. Tactical air bases with extensive maintenance facilities were needed to support two engine and four engine bombers, patrol planes, and Army aircraft that were integral to the amphibious operations against entrenched Japanese forces throughout the island chains. Thus, while the CASU program began as support for carrier aircraft only, the strategic circumstances of the war required the Commander, Naval Air Forces, Pacific Fleet (COMNAVAIRPAC) to modify CASU maintenance responsibilities to include land-based aircraft in addition to carrier aircraft. Thus, in October 1944 the definition of the acronym CASU was changed to Combat Aircraft Service Unit (Forward). From that point forward, the CASU (F) serviced both carrier and patrol aircraft, to include Army Air Corps and Allied units.[304]

During the second half of 1942 another significant change in aircraft maintenance operations occurred. The increase and intensity of aircraft operations in the Pacific after

[303] "CASU: Carrier Aircraft Service Unit," 14–18.
[304] "CASU Training Manual of the ACORN Assembly and Training Detachment," 1; "Operational Experience of Fast Carrier Task Forces in World War II," 36.

the Battles of Wake Island and Midway Atolls made it clear that the navy needed an aircraft engine overhaul facility in the South Pacific. The CASUs alone, were insufficient to complete the increasing number of overhauls. Aircraft engines that required major overhauls had to be shipped 3,000 miles from the South Pacific to Pearl Harbor due to the inability of the CASUs to keep up with the demand. This took up valuable shipping space on merchant and naval vessels and placed the units out of commission for weeks or months.[305] Ironically, the duration of labor involved on a major overhaul was only a matter of a few days to a week. Recently promoted from Chief of BuAer to Commander, Air Forces, Pacific Fleet, and given a third star, Vice Admiral (VADM) Towers endorsed a request sent to the Navy Department for an overhaul facility in the southern Pacific operating area. He commented on the necessity for such a capability on the front lines:

> Experience during the past several months has clearly demonstrated the immediate necessity for establishing in the South Pacific overhaul facilities for aircraft engines, propellers, and power plant facilities…. Action is necessitated by lack of sufficient pool of spare engines to permit the rotation of engines for overhaul between the South Pacific and established facilities at Pearl Harbor or the West Coast…. The need for prompt action is shown by the fact that more than three hundred and fifty (350) replacement engines have been shipped to the SoPac [sic] whereas only about fifty (50) have been returned to overhaul bases to date. The drain on the engine pool, if continued, may soon result in critical shortages which will hamper operations.[306]

[305] "Aviation Repair and Overhaul Unit 5," April 17, 1946, 1, RG 38 "World War II War Diaries," NARA II, https://www.fold3.com/image/302084329.
[306] As quoted in "Aviation Repair and Overhaul Unit 5," 1.

By December 1942, the navy had called two officers to Washington D.C. to begin planning what would become the navy's Aviation Repair and Overhaul Units (AROU). CDR Thomas D. Guinn and LCDR Seraphin B. Perreault were ordered to the Office of the Vice Chief of Naval Operations. They soon brought three other officers in to assist with standing up the new unit. LT F.A. Celler, USNR was nominated as the Aviation Repair Officer, LT J.V. Koch, USNR, was placed in charge of Personnel, and LT R.S. Jennings, USNR, was assigned as Supply Officer. Their goal was to design a system that could complete 100 major overhauls per month while positioned in the forward operating areas of the Pacific. The concept of an AROU began to take shape and units began forming within a few months.[307] AROUs were commissioned at various times throughout 1943-1944.

AROU-1 was commissioned in August 1943, but did not forward deploy into the Pacific until April 1944. AROU-1 was given orders to transfer from Alameda, California, to the Admiralty Islands, located just to the north of Papua New Guinea.[308] Another smaller repair unit, designated AROU-2, was requested in February 1944 by Admiral Nimitz, who had been promoted to Commander in Chief, Pacific Fleet (CINCPACFLT) after the attack on Pearl Harbor. AROU-2 was commissioned in March 1944 with CDR Norman O. Anderson as its first, and only, wartime Commanding

[307] "Aviation Repair and Overhaul Unit 3," April 17, 1946, RG 38 "World War II War Diaries," NARA II, https://www.fold3.com/image/1/302084326.
[308] *Two Degrees from the Middle: The History of Aviation Repair and Overhaul Unit Number One in World War II* (St. Paul, MN: Bronson West, Advertising, 1945). The units were called Major Aircraft Repair Squadrons (MARS) but in late spring 1943 the designation was changed to Aviation Repair and Overhaul Unit (AROU).

Officer. AROU-2 was assigned to Roi, Kwajalein Atoll, in the Marshall Islands.[309] The navy commissioned a total of five AROUs throughout the South Pacific during the War.

An AROU was completely self-sufficient, similar to a CASU, but on a much larger scale. Over 1,000 sailors were assigned to AROU-1, with approximately four-fifths, or around 800, being aircraft technicians or part of the Supply Division within at the AROU. Some large units, such as AROU-5, had 2,200 sailors assigned when operating at maximum capacity.[310] The rest of the sailors attended to the administrative duties and other non-technical ratings such as laundry, cooking, commissary, morale and welfare, shore patrol, fire-fighting, medical care, and religious duty. Other AROUs varied in size, such as AROU-2, which had about half as many personnel, 492 enlisted and fifteen officers.[311]

The primary role of the AROU was the assembly and repair of Pacific Fleet carrier aircraft. Major engine overhauls were only completed at select AROUs. AROU-2, for instance, was not designed to have an Engine Overhaul Division within its force structure.[312] Hundreds of technicians were handpicked from the naval air stations in the United States to serve in the technical divisions of the AROU. Furthermore, the AROU's labor force was sub-divided by specialization, similar to the aircraft carrier maintenance divisions.[313]

The Assembly and Repair Department was comprised of the following divisions: Planning and Materiel, Engine Overhaul, Accessories, Repair, Overhaul, Aircraft Pool,

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[309] "History of Aircraft Repair and Overhaul Unit Two," December 1945, 1–2, RG 38 "World War II War Diaries," NARA II, https://www.fold3.com/image/302002819. Accessed January 11, 2019.
[310] "Aviation Repair and Overhaul Unit 5," sec. Appendix E.
[311] "History of Aircraft Repair and Overhaul Unit Two," 2.
[312] "History of Aircraft Repair and Overhaul Unit Two," 1.
[313] *Two Degrees from the Middle: The History of Aviation Repair and Overhaul Unit Number One in World War II*.

Ordnance, Radio-Radar, Propeller and CO^2, and the Parachute Loft. Within each of the divisions, the technicians were further grouped by subspecialty. The Repair Division had its own carpenter shop, a paint shop, a fabric shop, a welding shop, a landing gear shop, and a machine shop. The Aircraft Pool Division divided its technicians into smaller groups like Structures, Hydraulics, Preservation, Turn-up, Electricians, Flight Line, and Flight Maintenance. Within the Engine Overhaul Division, technicians were grouped into Carburetors and Pumps, Mock-Up, Test Stands, Inspection, and Minor Overhaul. Specialization of labor was critical to the success of the AROU.[314]

Overhauled engines at the AROU were preserved for future replacements or for shipment out to aircraft carriers in the vicinity. Once the engines were deemed serviceable and all required maintenance or repair was complete, they were coated with anti-corrosion agent and placed in a moisture-proof bag. Dehydrating agent was then added, the excess air removed with a vacuum pump, and the bag was sealed. These engines were shelved and then delivered to the Fleet or placed into aircraft as necessary.[315] The processes were in accordance with BuAer's guidance on the proper way to preserve aircraft spare parts.

The Aircraft Pool Division was tasked with readying newly-delivered aircraft from transport carriers for transport. When "factory-new" aircraft were offloaded from transports at the AROUs, they were often in pieces, disassembled for shipping. Most of the time new aircraft were shipped by section in crates or other containers to save space in transit. The division technicians' daily routine was one of feast or famine. The division's job was to "unwrap" the new planes, assemble and "de-preserve" any parts that

[314] Ibid.
[315] Ibid.

might have been disassembled for shipment, make the final adjustments, perform functional checks, and wait for a squadron to show up that would ferry the airplanes to the carrier. Their job was to make preserved and overhauled planes combat ready in the shortest amount of time possible. The average time allotted for this task was 350 man-hours per plane.[316] Between mid-September 1944 and 1 January 1945, the Aircraft Division of AROU-1 furnished approximately 800 combat-ready aircraft to the Fleet. [317]

Of the five AROUs commissioned by the navy during the war, the oldest unit, ironically designated as AROU-5, was completing its first engine overhauls in June 1943. Its first month output was only seven overhauls, a far cry from their goal of 100 per month. But by January 1944, AROU-5 technicians reached their goal with 103 and never looked back. (Table 5-2)

Table 5-3: AROU-5 Summary of Engine Overhauls July 1943-February 1945[318]

Month	Major Overhauls	Minor Overhauls	Total
June 1943	6	1	7
July 1943	36	5	41
August 1943	80	2	82

[316] Commander, Air Force Pacific Fleet, "Analysis of Pacific Air Operations, June 1944," July 27, 1944, 60, RG 38 "World War II War Diaries," NARA II, https://www.fold3.com/image/1/280033241. accessed May 13, 2019.
[317] *Two Degrees from the Middle: The History of Aviation Repair and Overhaul Unit Number One in World War II*, sec. Aircraft Pool Division.
[318] "Aviation Repair and Overhaul Unit 5," Appendix B.; It should be noted that of the 2,184 "major" overhauls in Table 5-2, 1,003 were on the Pratt and Whitney R-2800 engine, predominantly used in the F6F *Hellcat* fighter. The remaining 1,181 were conducted on the R-2600 and R-1820 models both built by Curtiss. These engines were used in various naval and Army aircraft, but predominantly in the SBC *Helldiver*, the Brewster F2A *Buffalo*, the Grumman F3F, and early models of the F6F. The focus of effort by the AROU was the Navy's carrier aircraft. The number of engines undergoing overhaul at just one of these units is indicative of the wear and tear fleet operations were having on airplanes. See "Aviation Repair and Overhaul Unit 5."

September 1943	58	3	61
October 1943	62	21	83
November 1943	66	30	96
December 1943	55	12	77
January 1944	70	33	103
February 1944	85	42	127
March 1944	97	20	117
April 1944	110	36	146
May 1944	125	34	159
June 1944	150	60	210
July 1944	120	47	167
August 1944	142	46	188
September 1944	105	33	138
October 1944	161	22	183
November 1944	176	31	207
December 1944	163	7	170
January 1945	185	17	202
February 1945	132	59	191
21 Months	2184	561	2755

An analysis of Table 5-2 supports the argument that the navy's air force was not fully prepared to go to war when it did. As the backlog of engines in 1942 raised concern with Towers and other naval leadership, the lack of maintenance infrastructure and available

labor did little to assuage their worry. The United States victory at Midway served as an indication of what was to come in terms of necessary aircraft maintenance. Perhaps the navy realized the effort it would take to keep the carrier fleets at full strength when so many aircraft were engaged in combat? More combat missions equaled more overhauls. It was not until a year later that the AROU began completing engines overhauls and six months after that before their production surpassed one hundred per month.

The timing with which the AROU began to deliver large quantities of engines was consistent with the timing at which naval aircraft technicians were graduating at the highest rate since LCDR Wheelock overhauled the trade school programs.[319] It also coincided with the opening of the Naval Training Centers in Norman and Memphis in September 1942. The six-month average for each rating's course of study places the largest numbers of available around the same time that the AROUs were completing the most overhauls. The skilled labor that made up the AROUs and CASUs were graduates from the aviation trade schools managed by LCDR Wheelock's Technical Training Division in BuAer from 1940-1942.[320]

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AROU-5's monthly production of overhauled engines was representative of the other four AROUs' forward deployed in the Pacific. The number of engine overhauls completed each month in 1944 supports the notion that the aircraft technician played a substantial role in the strike missions of the Fast Carrier Task Forces. The navy's Fast Carrier doctrine was as much dependent on the aircraft technician as it was on the

[319] See Table 3-1.
[320] In February 1943, CDR Austin Wheelock left BuAer and assumed command of the seaplane tender USS *Matagorda* (AVP-22) and would serve a follow-on tour on Towers' staff at Commander, Naval Air Forces, Pacific Fleet. See "Captain Austin Wadsworth Wheelock, U.S. Navy," BuPers, 1945.

officers and technology of the U.S. Navy. If the engines and airplanes were not available when needed, the carriers were worthless.

A "major overhaul" was routinely conducted after 500 flight hours.[321] An average sortie could be anywhere between two and three and half hours, depending on the mission and aircraft. A standard combat mission for an F6F was usually three or three and a half hours.[322] Therefore, 500 engine hours equated to somewhere between 140-250 flights, or five to nine months if we limit aircraft to just one sortie per day. However, in 1944 and 1945, the average number of flights per aircraft per month for fighters was 15 and 17, respectively, based on reports after the war from the Fast Carrier Task Force.[323] This equates to approximately 45 hours per month. At this rate, an aircraft engine would reach its overhaul limit in about eleven months. Therefore, if the engines started arriving for major overhaul at the AROUs in late 1943 or early 1944, then it is plausible that that it was not until after Midway, perhaps early 1943, that the navy started increasing its flight operations to its highest since the war began. What significance does this have in terms of aircraft technicians?

Importantly, it correlates with the period of highest graduation rates of the NATTC trade school, November 1942 through March 1943 (see Table 3-1). The timing of the increased output of the trade schools, combined with the establishment of NATTC, plus the ever-increasing aircraft carrier construction and associated aircraft deliveries throughout 1943, made it possible for the navy to modify its operational doctrine. By

[321] 500 hours was the typical allowance before a major overhaul was required, but could vary with aircraft model. See *Bureau of Aeronautics Manuals*, 1940-1945.
[322] "Aircraft Action Report, Fighter Squadron Thirteen," September 25, 1944, RG 38 "World War II War Diaries," NARA II, https://www.fold3.com/image/1/295408183.
[323] "Operational Experience of Fast Carrier Task Forces in World War II," 51.

then, the maintenance support was in place to support intensified flight operations and eventually implement the Fast Carrier Task Force concept.[324]

While the navy had carriers in operation in 1942 and 1943, the majority of aircraft carriers were constructed in 1943 and commissioned in 1944. Overall, carrier flight hours were much lower in 1942-1943 compared to that of 1944-1945. Just 6% of the navy's carrier-based aircraft combat sorties occurred during the first twenty-four months of World War II. This equates to 7,381 of the approximately 116,000 combat or "action" sorties flown by air groups assigned to aircraft carriers before January 1, 1944.[325] The number of engine overhauls that the AROUs completed were also lower in 1943 than in mid-1944 or 1945.[326] The higher rate of flight hours correlated directly with the timing of increased aircraft carrier inventory. The correlation was of a materiel nature; more planes and more carriers equaled more flight time. More flight time equaled more overhauls. But the data hints at a more complex reason behind the dramatic jump in overhauls and flight hours than simply materiel availability and doctrinal change. It suggests that the availability of a well-trained and sufficiently sized technical labor force directly affected the navy's ability to engage in a protracted naval air war in the Pacific.

The U.S. naval air war against Japan did not achieve sustained success until enough technicians were in place to support the doctrine of the Fast Carrier Task Force. Based on BuAer's development of technical training from 1940 through 1942, the U.S. Navy did not have enough manpower to back a high operational tempo of flight hours

[324] For a more complete account of the operational and doctrinal history of the Fast Carrier Task Force, see Clark Reynolds, *The Fast Carriers: Forging of an Air Navy* (Naval Institute Press: Annapolis, MD, 1968).
[325] "Operational Experience of Fast Carrier Task Forces in World War II," 51. These numbers did not reflect non-combat training, maintenance, or logistics flights for either period
[326] See Table 5-2.

and fast carriers. But the general timing of qualified technicians reaching the Fleet in mass quantities in 1943 does appear to coincide with a shift in the navy's strategy and increased success in the Pacific. Although this was not the sole reason for the shift, it should not be ignored.

Significant and sustained carrier operations did not occur until the Guadalcanal Campaign (August 1942-February 1943). This, combined with the fact that sortie rates and flight hours were so low in 1942 and 1943 compared to the last two years of the war, suggests that the navy was not ready to fight a protracted war at sea until its carrier aircraft technicians were trained and in place. Thus, we must reconsider the completeness of the arguments that have claimed it was the technology behind the planes and carriers, or the bravado of the pilots and admirals that was most responsible for the United States' naval victory in the Pacific. Without enough technicians to manage the repairs, overhauls, and replacements that a Carrier Task Force required, the effectiveness of the Fast Carrier doctrine implemented in 1944 would have been severely limited

Chapter 6: A Throw-Away Culture

When President Franklin Roosevelt requested that Congress declare war on Japan on 8 December 1941, the navy entered into an air war for which it was not prepared. The trajectory of the war did not suddenly shift in the summer of 1942. Historiographical arguments that only cite specific battles or campaigns as turning points in the war neglect to realize the complete picture behind carrier aviation in World War II. The famed Battle of Midway, was indeed a great victory.[327] Giving sole credit to the navy's accomplishments in combat fails to recognize the remarkable contribution that naval aviation maintenance had on the outcome of the Pacific War. Therefore, we must take a closer look at various data sets that bolster the argument that naval aviation maintenance, and the technical labor force that supported it, was instrumental in the U.S. naval victory in the Pacific.

However necessary to American naval success the technician was, aircraft repair at sea became less and less important to the navy as the war moved into its latter stages. As aircraft and shipbuilding companies on contract with the navy realized their full production potential by 1944, it was easier to just exchange damaged airplanes with replacement ones in order to keep the carrier's air group at full strength. With so many spare airplanes available, the navy could simply "offload" aircraft that were not mission-capable, and replace it with a new one awaiting delivery from a local CASU. In essence,

[327] See John Parshall and Anthony Tully, *Shattered Sword: The Untold Story of the Battle of Midway*, (Potomac Books, 2005) for a more comprehensive discussion of the historiographical misinterpretations about the Battle of Midway.

U.S. naval aviation transitioned to a "throw away" culture in the last years of the war due to the abundance of available replacement aircraft.

There is a direct correlation between the timing of increased technician manpower and the numbers of aircraft delivered from factories. The timing of this surge correlated with an increased supply of spare parts and aircraft, through standardization and improved technology. The rate at which the navy spent its allocated aviation funds on aviation also coincided with the expansion of its aviation labor force. Three sets of statistics—inventories of personnel, aircraft, and aircraft carriers—deliver a solid backing to the argument that technicians had a critical role in the development of the navy's carrier warfare doctrine when studied in aggregate.[328]

First, by analyzing the number of non-flying aviation personnel (which can be reasonably inferred as mostly technicians) alongside the number of carrier aircraft the navy had on hand, a ramp up in relation to each other is evident. A year before the war, the number of active duty enlisted aviation personnel was approximately 7,000. That number doubled to 14,000 by the end of 1941, and more than quadrupled to 63,000 in 1942. In 1943, it increased more than twice, reaching 144,000; a year later the strength of the enlisted aviation ranks stood at 215,000 sailors. By August 1945, the navy claimed an enlisted aviation force of 248,000 men and women.[329]

As noted above, when 1942 drew to a close, the total number of enlisted aviation personnel had quadrupled. This was only a numerical increase of about 50,000, but no other year during the war saw a rise at this rate. BuAer and BuPers also completed the biggest revisions to its aviation technical training programs during that year. In March

[328] See table 6-1.
[329] "Annual Report of the Secretary of Navy: Fiscal Year 1945," 21–22.

1942, the trade school at NAS Jacksonville adjusted the timing of its school day to handle two groups of students by implementing a two-shift schedule, doubling their graduation rates. Construction on NTC Norman and NTC Memphis was soon completed and courses began in September 1942. Basic naval aviation technical schools were geographically consolidated from nine locations down to four. The greatest change to the system of aviation technical training was bringing all administrative control under one roof when NATTC was established with Rear Admiral A.C. Read in command.[330]

After NATTC took over the technical education of the enlisted technician, the ranks of maintainers headed to the Fleet continued to grow, increasing a little over two times, amounting to some 80,000 additional sailors. At the same time, aircraft carrier and airframe deliveries also rose. The navy's total aircraft carrier inventory doubled in 1942 and then tripled by the end of 1943. Simultaneously, by December 1943, the number of naval fighter aircraft on hand increased ten times since the start of the War. The vast increases of aviation materiel in 1942 and 1943 coincided with a similar rise in personnel availability. As aircraft and ship manufacturers were producing multitudes of airplanes and carriers, BuAer and BuPers were struggling to keep up with delivering their own product to support the war effort—the aviation technician. (See table 6-1)

[330] Haley *op. cit., 19.* See chapter 4 for more details and references to technical schools and the establishment of NATTC.

Table 6-1 USN Aviation Personnel and Materiel on Hand, 1940-1945[331]

	12/40	**6/41**	**12/41**	**6/42**	**12/42**	**6/43**	**12/43**	**6/44**	**12/44**	**6/45**
Aviation Personnel	7,204	10,439	14,848	26,947	63,521	104,858	144,198	182,872	215,739	240,303
VF	245	349	514	736	1,253	2,246	5,281	10,037	11,849	13,940
CV	6	6	7	5	4	7	10	13	16	20
CVE	0	1	1	2	12	19	35	63	65	70
CVL	0	0	0	0	0	5	9	9	8	8

If this data is depicted in graphical form, it is apparent that the rise in aviation personnel was followed closely with an increase of both aircraft and carriers:

[331] "Annual Report of the Secretary of Navy: Fiscal Year 1945," 21,31,55. Fighter data is total number owned by the Navy, not total deployable. Aircraft Carrier inventory determined how many aircraft could be put to sea at one time.

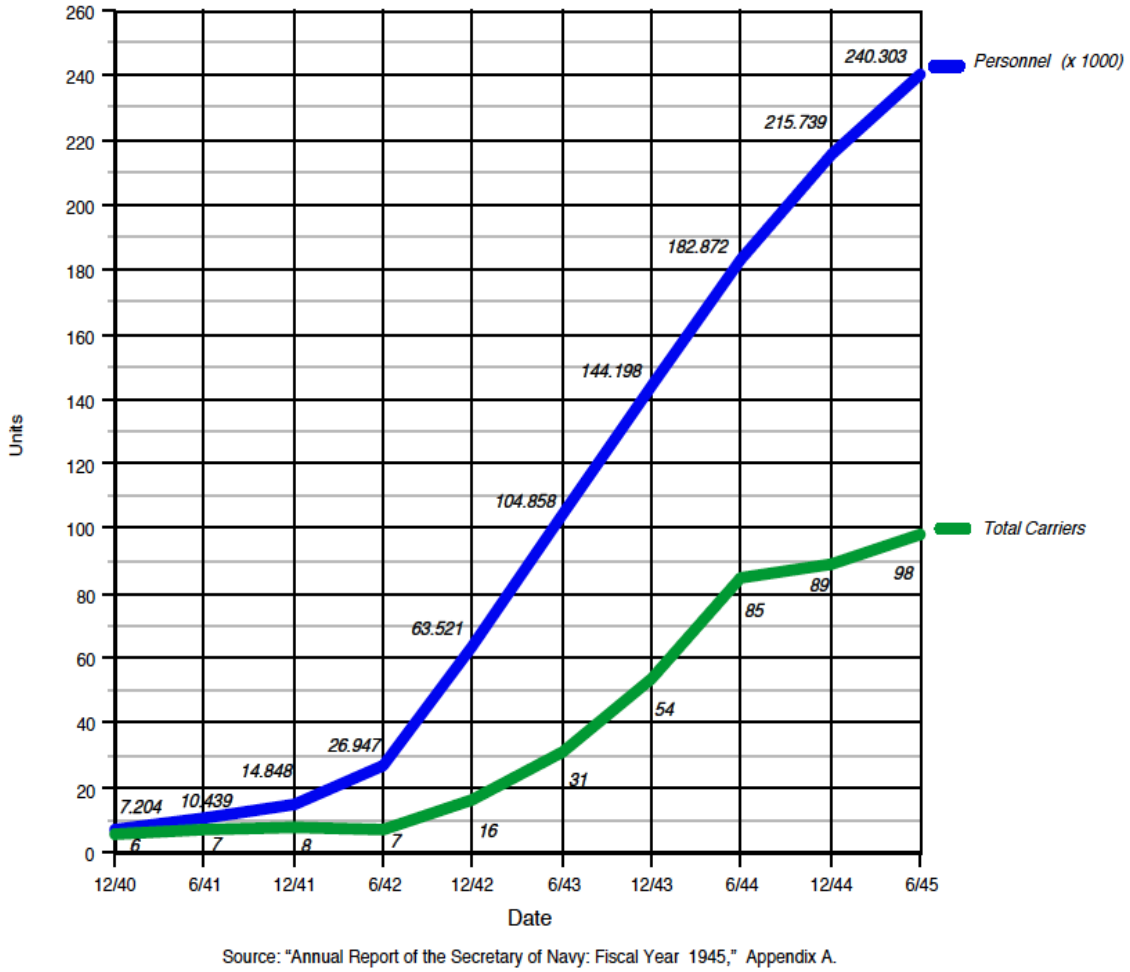
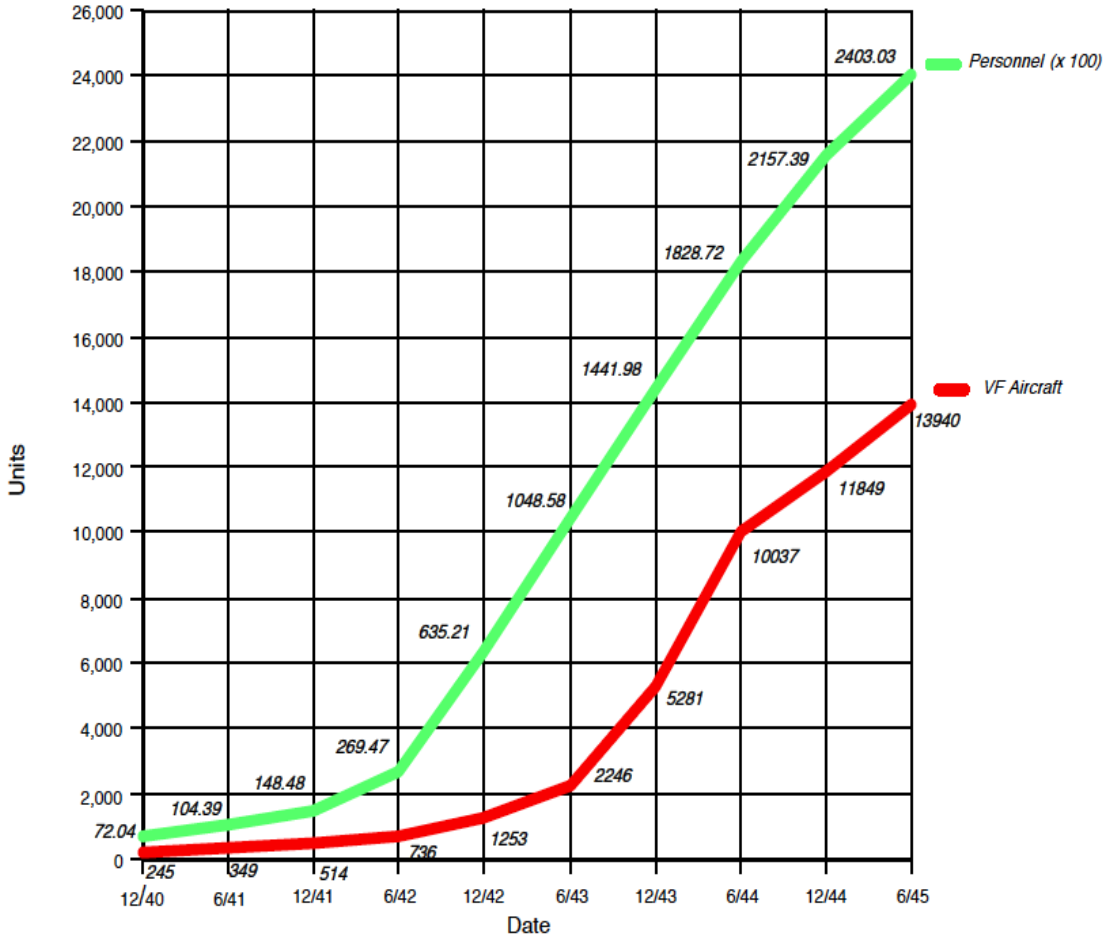


Figure 6-1: Aviation Personnel vs. Aircraft Carriers over Time



Source: "Annual Report of the Secretary of Navy: Fiscal Year 1945," Appendix A.

Figure 6-2: Aviation Personnel vs. Fighter (VF) Aircraft over Time

The slopes of the VF and CV lines begin their sharpest rise on the horizontal axis in late 1942-mid 1943. In both Figure 6-1 and Figure 6-2, this occurs less than a year after the personnel numbers begin their upward trend in the summer of 1942. The comparable rise of new aircraft carriers and aircraft coincided with an associated surge of trained aviation technicians.

The first major increase in the number of carriers did not begin until after June 1942. The introduction of the escort carrier (CVE) is the main reason for changing the

slope of this graph in 1942 as U.S. inventory went from two to twelve in a period of six months. Note the similar rise in personnel during that period (Figure 6-1).

Similarly, fighter procurement makes its first minor upward swing at the same time. The navy began contracting with Grumman for the F4F *Wildcat* fighter in 1940 and continued renewing the contract as new and improved variants were developed. The first operational F4F was delivered to the navy in December 1940. From then on, airframe deliveries began at ten per month and increased to twenty-seven per month by the end of the year. 1942 brought with it a further increase in the production rate to an average of forty to fifty per month. Some models of the F4F were produced at much higher rate, amounting to 130 per month at the end of 1942. In total, the navy purchased 1,714 F4F *Wildcat* fighters for a combined total of $79 million, not including complete spares or spare parts.[332] When placed side by side, the surge of technicians correlates with a similar expansion of aircraft and aircraft carriers by the end of the war's first year (Figure 6-2).

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Materiel expenditure factors also support the argument that labor and material costs affected the way carrier maintenance was performed. Similar to buying a new car, airplanes came with options—and price adjustments to go along with those options. The navy's aircraft contracts were broken down by basic airframe, engine, propellers, radio and radar, instruments, armament, and miscellaneous equipment. Within each group,

[332] $79 million in 1941 equates to $1.3 billion in 2019 dollars. Price quoted is for airframes only. Calculation based on average inflation rate of 3.71% between 1941-2019. Source: U.S. Bureau of Labor Statistics.; The F4F *Wildcat* was built by Grumman until 1943. Beginning in 1942, General Motors began a *Wildcat* production line based on Grumman's design, but redesignated the airplanes as FM-1 and FM-2 *Wildcats*. *Wildcat* manufacturing ended in 1945.

there was a price for installation of the part, a price for a complete spare, and another price for the spare parts associated with each system. The table below lists the average costs associated with the F4F-3 and F6F-3 fighters as of January 1944:

Table 6-2 Average Unit Aircraft Prices, Navy F4F vs F6F, January 1944[333]

Part	**F4F-3, -4** ($)	**F6F-3** ($)
Airframe	25,500	53,500
Airframe Spare Parts	7,650	16,050
Engine (Installed)	15,283	19,228
Engine Spare	7,642	9,614
Engine Spare Parts	8,253	8,268
Propeller (Installed)	4,199	2,215
Propeller Spares	2,519	1,329
Propeller Spare Parts	1,209	638
Radio-Radar (Installed)	2,600	4,450
Radio-Radar Spares and Spare Parts	2,600	4,450
Instruments (Installed)	1,120	1,100
Instrument Spares	338	310
Instrument Spare Parts	112	100
Armament (Installed)	3,321	5,025
Armament Spares	699	1,073
Armament Squadron Equipment	90	91

[333] "Bureau of Aeronautics Average Unit Contract Prices - Navy Airplanes," January 1, 1944, 1, Carriers Collection, Box 13, NHHC.

Miscellaneous Equipment (Installed)	1,470	1,600
Miscellaneous Spares	500	560
Miscellaneous Spare Parts	230	240
Complete Aircraft (no spares or spare parts)	53,583	87,209
Complete Aircraft (with spares and spare parts)	85,335	129,841

The unit price varied depending on mission capabilities within each model, but Table 6-2 shows the average cost determined by BuAer in 1944. For example, an F4F airframe alone ranged from $26,000 to $53,000 (engines, propellers and spare parts not included.)[334,335] It was not until the summer of 1943 that the navy saw the massive deliveries of fighters to the Fleet with the introduction of the Grumman F6F *Hellcat*. At $30,000 to $45,000 more per aircraft, fiscal considerations began to impact maintenance practices.

The first contract for the F6F was let in May 1942 for seventy airplanes at an airframe-only price of $37,900 each. Grumman delivered all seventy that August. Over the next three years, a total of almost 14,000 F6F *Hellcats* would show up in the navy's inventory, ranging in price per unit between $37,000 to $63,000, depending on the model. Worth noting is the fact that price per airframe went down as the number ordered went up. The first contract for the F6F, signed on Christmas Eve in 1941, was for 1263 aircraft at a unit cost of $63,600 each. A second contract for 7,139 F6Fs in August 1942 lowered

[334] $445,000-$907,000 in 2019 dollars.
[335] "Bureau of Aeronautics Analysis of Naval Production Airframe Contracts."

the price to $39,100.[336] The airframes promised in this contract were delivered throughout 1944 on an average of 500 per month.[337]

As with any machine, spare parts are essential. When purchasing airplanes from Grumman, the navy contracted for spare parts as well. Specifics on what parts were considered in the package is not available, but the percentage of parts included is. The F4F contract included an average of 22% spare parts with each plane, meaning that much of the airplane was available for replacement by technicians. That same figure dropped to 16% in the newer F6F contracts.[338] What caused this change?

There are several possible reasons for the change in percentage of spare parts but it is difficult to ascertain which is most responsible. Initially, I would surmise that as with anything in the weapons industry, technology improved over time and the airplanes became more reliable as they were developed. The average addition of spare parts for an F4F was $32,000. A spare parts kit for the F6F averaged $43,000. Fiscally, it made sense to order fewer spare parts with each unit, because on the whole the number of F6F deliveries were nine times more than the F4F, and cost about $34,000 more for the basic aircraft priced at $53,583, compared to $87,209.[339]

Another possible reason is that with such a large contract on the F6F, and with the planned number of aircraft to be delivered, BuAer preferred to scrap a broken plane then spend the labor man-hours to fix it. With the number of fighters that the navy was planning to have in reserve, why spend the money on spare parts when it would be easier

[336] $633,000-$1,078,000 in 2019 dollars. Prices are for airframe only, spare parts, engines, etc. are not included.
[337] "Bureau of Aeronautics Analysis of Naval Production Airframe Contracts."
[338] Percentage of spares varied for different versions of each fighter from 15-30 on F4F and 9-22 on F6F. Source: "Bureau of Aeronautics Analysis of Naval Production Airframe Contracts."
[339] "Bureau of Aeronautics Average Unit Contract Prices - Navy Airplanes." See Table 6-2.

to push the broken plane over the side and bring up a new one from the hangar or fly a new one in from a CASU? As far back as 1927, the navy had toiled with the idea that replacing carrier airplanes was a better investment in time and money than fixing them. In a letter from (then) Rear Admiral William V. Pratt, President of the Naval War College, to Chief of Naval Operations Admiral Edward W. Eberle on the subject of "Airplane Carriers," Pratt stated that he concurred with BuAer's recommendation for the next generation of aircraft carrier design to consider that carrier maintenance crews only conduct minor aircraft maintenance while underway. "Shop facilities - Concur in Bureau of Aeronautics reasoning, to provide for only top maintenance. The essential thing is to get planes in the air at the critical time. Let repairs come later, or abandon planes."[340] The navy knew then that planes in the air were more valuable than planes in repair. However, the logistics of making such recommendations a reality would take more effort than simply words on paper. Supporting a maintenance program that was consistent with such a policy required a fully mobilized aircraft industry outside the navy and an efficient supply chain within the navy—neither would be available until at least the second year of World War II.

The last consideration is the impact of the technical schools at the time a contract was written. On the F6F, the first contract was written in May 1942 and included 22% spare parts. In December 1943, that dropped to 16% and in February 1944, it was only at 10%.[341] When NATTC was established in September 1942 and took over the technical training program, the numbers of technicians available to the Fleet increased

[340] William Pratt, "Airplane Carriers," Correspondence from President, Naval War College to CNO, April 11, 1927, Carriers Collection, Box 1, NHHC.
[341] "Bureau of Aeronautics Analysis of Naval Production Airframe Contracts."

dramatically. I believe there were two possible but mutually exclusive reasons for the decrease in spare parts in relation to NATTC training.

The most conservative, or what could be deemed "positive," reason would have been a result of the internal operations of the schools. Once technical training was standardized and centralized under NATTC, BuAer's expectation very well might have been that the quality of training and overall technical skills of the graduates would have improved. Thus, better trained technicians would inevitably have an immediate impact on keeping airplanes flying. This would mean fewer replacements. After all, the mark of a good mechanic is one who can diagnose and fix a problem, rather than just replace a part. According to BuAer's Training Division, the newly trained technicians would be better than those of previous years. LCDR Wheelock offered this as early as January 1942 when he included comments to that effect in his lecture on how BuAer was managing the new training requirements that accompanied the increased size of the Fleet and the number of naval aircraft. In effect "… instruction must not only be as good as it was before, but it must be better… text books are supplements by visual and aural aids which, we hope, will guarantee that the required subjects are learned one hundred percent."[342] Perhaps in the mind of the BuAer acquisition team, as the technical training program matured, carrier aviation maintenance would improve altogether.

Yet, when studying the situation a year later, it is more believable that BuAer realized in order to keep up with the increased pace of the war in the Pacific, it would have to err on the side of caution -- repair less and replace more. One tangible fact that supports this suggestion is that in 1943 BuPers lowered the minimum GCT scores for

[342] Wheelock, "Lecture on Duties of Divisions in the Bureau of Aeronautics, Navy Department," 6.

entry into certain aviation ratings.[343] Lowering the minimum standardized score entry criteria would no doubt inflate the number of students and thus graduates. But it might also be damaging to the effectiveness of the overall labor force. The minimum score for entry into the AMM rating declined from sixty-two to fifty-two. The AO rating dropped from seventy to fifty-two.[344] BuPers may have reduced it to increase acceptances, but even so, BuAer might have seen this as having far-reaching impacts. It is very reasonable that BuAer saw this as a downgrade in technical acumen of its incoming technicians. Therefore, if the financial means were there, why waste time repairing aircraft when it could just as easily replace them? That way, technicians could focus on routine service and maintenance for everyday flight operations.

According to spending reports, BuAer did have the funds to procure many more aircraft in 1942-44. Buying more aircraft would ultimately require less repair and fewer spare parts. The increased dollar value on fighter aircraft deliveries alone in the twelve months between December 1942 and December 1943 grew by a factor of over six as Table 6-3 shows.[345]

Table 6-3: Semi-annual Value of Navy Fighter Aircraft Deliveries through June 1945[346]

Date	**Dollar Value**	**VF Aircraft Deliveries**
12/40	$3,711,000	64
6/41	$8,566,000	153
12/41	$10,911,000	189

[343] "US Navy Interviewer's Classification Guide, NAVPERS 16701."
[344] Ibid.
[345] "Annual Report of the Secretary of Navy: Fiscal Year 1945," 53.
[346] Ibid.

6/42	$29,141,000	520
12/42	$56,933,000	874
6/43	$132,327,000	1622
12/43	$316,533,000	3823
6/44	$449,206,000	6616
12/44	$413,641,000	5459
6/45	$510,901,000	6182
Total	$1,921,148,000	25,362

Carrier aircraft served no purpose when they could not fly. Similar to rounds left in a chamber, they were of little use other than deterrence when sitting on the deck of an aircraft carrier in a "hot" war. In 1943, the navy contracted with Grumman to receive nearly 600 new F6F each month. The most F4Fs delivered per month was 209, which occurred only in the last three months of 1942. The remainder of 1942's monthly deliveries hovered around fifty each.[347] The question that undoubtedly troubled Wheelock, Radford, and perhaps Towers in 1942 was whether or not the navy's aviation technicians could keep that many new fighters flying, let alone the additional obsolete aircraft such as F3Fs that were still in service. With little concern for funding, the most reasonable solution was to spend less on spare parts, save money and labor hours, and use those funds on entirely new airplanes.

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[347] "Bureau of Aeronautics Analysis of Naval Production Airframe Contracts," 1.

The technicians on the carriers were intended to spend their time on Class D maintenance, engine changes, and component installations.[348] Engine changes were normally routine after a certain number of flight hours, or if a simple repair was not possible. A few hours of labor to remove a malfunctioning engine and replace it with a new one out of the box made the most sense. Each airframe contract from the manufacturer came with a specified number of replacement engines. Developing a maintenance philosophy that removed the burden of repair on the at-sea technician and shifted emphasis towards replacement gave the navy an edge. Removing the trouble of major engine and airframe repair from the carrier-based maintainers and moving it to the land-based CASU and AROU was crucial to the efficiency of the navy's aviation maintenance program. But in order for these units to function effectively, supply had to be sufficient to meet the demands of the Fleet.

In June 1943, twice-retired Admiral Henry E. Yarnell was recalled to his third tour of active duty in the Office of the Chief of Naval Operations.[349] His first task (and arguably, the primary reason for his hire) was to conduct a Fleet-wide survey of aviator and non-aviator officers as to the status of naval aviation. Yarnell titled the subject of his findings in a memorandum under the subject "Report on Naval Aviation." The stated purpose of the survey was to receive "comment, constructive criticism, and suggestions as to means and methods by which the efficiency of naval aviation could be

[348] Stubblefield, "Carrier Aircraft Maintenance Is Really Tough," 106.
[349] "Harry Ervin Yarnell," Naval History and Heritage Command, accessed April 9, 2019, https://www.history.navy.mil/research/library/research-guides/modern-biographical-files-ndl/modern-bios-y/yarnell-harry-ervin.html.

improved."[350] The subject of aviation logistical support had forced the navy to look closer into the ways it was conducting "business."

Yarnell solicited responses from 300 officers but only received 127 replies. Although the response was less than 50%, Yarnell claimed to have received valuable information from those that chose to respond. As far as aircraft maintenance was concerned, one of the many subjects he was tasked to report on--supply chains and spare parts availability--stood out as the most critical issue affecting carrier air group's readiness. Yarnell summarized the general reaction of the aviation community concerning supply by stating that "There was much criticism in the letters concerning the supply system, lack of spare parts, slowness of delivery, etc. This has resulted from lack of production of adequate spare parts, and slowness in their distribution. The result is that many planes are out of service due to lack of spares. This situation should be remedied as quickly as possible."[351]

Yarnell's report was long in coming. The logistics quandary was addressed a year earlier when Vice Admiral Towers, COMAIRPAC, had called for establishing overhaul and supply pool facilities in the South Pacific in support of carrier and land-based aviation operations. His comments pointed to an established deficiency in naval aviation's supply chain: "Action is necessitated by lack of [a] sufficient pool of spare engines to permit the rotation of engines for overhaul …"[352] Yarnell's report showed little improvement in the nine months since Towers had spoken out.

[350] Henry E. Yarnell, "Admiral H. E. Yarnell, USN (Ret.) to the Secretary of the Navy.," Memorandum, November 6, 1943, 1, RG 72, Entry 172, Box 1, Stack 470, NARA II.
[351] Yarnell, 5–6.
[352] "Aviation Repair and Overhaul Unit 5," 1. See chapter 5 for full quote.

One unnamed flag officer (the surveys were completed anonymously) responded to Yarnell's query by asking "Who is responsible for logistics to the extent for insuring that aircraft suitable in numbers and types, armament, equipment and supplies are available and maintained in quantities successfully to establish a war plan? Obviously, the answer is 'No one.'" A more measured response from one junior officer stated "The system of supply is very deficient, especially in the procurement and distribution of spare parts. In this particular squadron, three planes have been out of commission for over a month due to the shortage of propellers." Another disgruntled lieutenant offered "We have to use every trick we can think of to get what we want from supply when they should be doing everything in their power to anticipate our needs and get it to us. I'm now scheduling flights for a thirty-six plane squadron. Twenty-four planes are the most I can count on. This is only 66%..." Another lieutenant argued "A great number of our planes are kept grounded for lack of spare parts, either because the parts are not manufactured in quantity, or because of poor distribution."[353] Spare parts and the logistics of getting them to the squadrons at war were a challenge in 1942-1943, but 1944 saw a better system emerge with the establishment of the CASUs and the AROUs throughout the Pacific.

The CASUs and AROUs provided ready aircraft and spare parts to fleet units as a supplement to the spare parts loaded on the carriers. Before these units were in place, technicians aboard the carrier had to make do with what they had on hand in terms of spare parts and repair. By the time Towers had called for a better logistical support infrastructure throughout the Pacific, BuAer most likely realized that repairs on the

[353] Yarnell, "Admiral H. E. Yarnell, USN (Ret.) to the Secretary of the Navy.," 18.

carrier were more trouble than simply replacing an airplane with another that was prepositioned somewhere in the Pacific. If major repair or overhaul was required, after 1943, the navy could rely on its own capable maintenance staff at the AROUs and CASUs to complete such labor-intensive work, for it was then that the navy began to see modest gains in overcoming the deficiencies associated with a lack of trained aviation technicians in the Fleet. As previously shown in Table 6-1, the greatest increases of available technicians occurred in late 1943 and throughout 1944.[354]

1943 also brought with it a great advance in the technological sophistication of U.S. Navy carrier aviation with the introduction of the F6F *Hellcat* fighter. The airplane engine alone was an engineering marvel. To put it into perspective, up until this point in the war, navy carriers had been deploying with a mix of the Brewster F2A, the Grumman F3F, or the Grumman F4F. The F2A and F3F were each powered by a Wright R-1820 engine. The version installed in the F3F, an older aircraft, had a rating of 950 horsepower (hp). The 1820 in the newer F2A produced 1200 hp. In 1940, Grumman teamed up with Pratt and Whitney (PW) and used the PW R-1830 as the power plant for its newest fighter. Less than three years later, Grumman again subcontracted with Pratt and Whitney for the F6F and installed the R-2800 engine, which delivered a much more powerful 2200 hp capability.[355] The rapid advance in horsepower alone would be enough to challenge even the best veteran engine mechanic, which the navy was short of in 1942. What challenges would such advanced engine technology have on the aviation technician in the rapidly expanded Fleet of 1943-1945?

[354] "Annual Report of the Secretary of Navy: Fiscal Year 1945," 21.
[355] Friedman, *Fighters Over the Fleet*, 447.

Perhaps BuAer recognized the gravity of the situation and planned accordingly, preferring an overabundance of planes to spare parts. The contract that was signed in mid-1942 called for two lots of F6Fs, a total of 1,333 airplanes. The next lot of airplanes were contracted in December 1943 for a total of 7,139. The final F6F contract was let in February 1944 for 3,000 units.[356] A total of 11,472 F6F *Hellcats* were ordered by the navy in less than two years' time. Even if each carrier embarked only F6F aircraft (which never happened), the number of *Hellcats* outweighed the amount of available deck space the navy had on all of its carriers combined by the end of war by a factor of three.[357] The massive number of aircraft ordered was leading naval aviation maintenance to assume a more "throw-away" culture than it had ever embraced before. Perhaps BuAer and the Naval War College were correct in their assumptions back in 1927 that suggested the navy's aviation technicians would be better utilized in routine maintenance and servicing rather than making time-consuming major repairs.[358]

It seems as though someone in BuAer recognized this and adjusted accordingly. In a brief given by the BuAer Planning Division on 5 July 1944, it was stated that an average carrier air group consisting of ninety-one planes required an average of sixteen replacement planes per month to sustain combat operations. Nine were to replace aircraft losses--either operational or from combat--and seven were for worn-out aircraft based on number of combat deployments. This was a mix of attack planes (bombers/torpedo) and

[356] Bureau of Aeronautics, "Analysis of Naval Airframe Production Contracts," August 11, 1945, 1, NAVAIR Collection, Box 69, NHHC.
[357] Using 102 aircraft per CV, and 30 per CVL and CVE, I referenced table 6-1 and used the following calculation: (102x20)+(78x30)=4380.
[358] Pratt, "Airplane Carriers." *Op. cit.*

fighters, but over a typical multi-month deployment, it was a significant amount no matter what model aircraft it was.[359]

An "operational loss" was defined as something other than an aircraft being destroyed by enemy action.[360] Therefore, this might include pilot error, but it also could include aircraft malfunction. In the case that the pilot did save the aircraft in a malfunctioning situation and make the landing aboard the carrier, there was always a chance that it would still get dumped over the side and written off as a loss. In total, BuAer determined that sixty-six replacement airplanes were required to support an active carrier air group while engaged in combat operations during the war.[361]

As noted earlier, the more F6F fighters the navy bought from Grumman, the less expensive each unit cost. One could liken this to buying "in bulk" today. But the implications of this is what I believe encouraged a "throw away" culture amongst the carrier navy more than anything else. Labor cost for the navy to make repairs on carrier airplanes were minimal compared to the cost of an airplane or a replacement engine. For example, in 1943 a Petty Officer 2/c (E-5) working as an aircraft technician aboard an aircraft carrier overseas was paid a salary of $115.20 per month. If assigned to a shore command, his monthly pay was $96. But if he was also on flight orders (i.e. aircrew gunner or radioman) he would receive an additional fifty percent of his base salary, which equaled $57.60 more if assigned to a carrier.[362] Assuming a twelve hour workday

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[359] "The Program for Naval Aviation."
[360] "Operational Experience of Fast Carrier Task Forces in World War II," 73.
[361] "The Program for Naval Aviation." It is unclear how many months BuAer considered a task force to be actively engaged in combat according to the actual brief, but by 1944 the average carrier task force deployment was six months. Considering two to three weeks transit time on either side, the numbers average out to be nearly sixteen per month when "on station" in a combat zone. War is never an exact science, and BuAer most likely did its best to take all of these factors into consideration.
[362] "Taxes for Navy Personnel," *BUAER News*, September 1, 1943, 23, https://www.history.navy.mil/content/dam/nhhc/research/histories/naval-

while at sea and not a qualified aircrewman, the labor cost for an AMM 2/c was about forty-six cents per hour.[363] If, at maximum, ten Petty Officer 3/c worked eight hours to replace a bad engine, the labor cost would only be about $20. However, the spare engine itself cost around $9,600.[364] If that engine was needed before it had reached its maximum flight hours, would it really be worth the time and effort to remove a bad engine and replace it with a new one aboard the carrier?

The amount of time technicians would be unable to tend to routine maintenance duties if required to conduct multiple engine changes at sea would undoubtedly have a negative impact on the readiness of the air group's planes. In war, days engaged in combat are not always scheduled in advance. It was imperative that the carrier's air group was ready to fly with minimal notice. If sixteen replacement planes were delivered on a monthly basis to the carrier, then why not dump the broken aircraft or at least get them to an AROU or CASU for repair? Hangar and deck space on a carrier were at a premium. Keeping un-flyable aircraft on board did not make sense in the combat-intensive conflict fought in the Pacific against the Japanese.

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When the *Essex*-class carriers were first designed, the aircraft complement was intended to be eighty-three airplanes.[365] By the end of the war, some carriers were deploying with 102 or 103 aircraft as a standard load out.[366] An additional twenty aircraft most likely left little room for maintenance or extra spare parts. This would also have an

aviation/Naval%20Aviation%20News/1940/pdf/1sep43.pdf. Accessed April 11,2019.; This equates to approximately $1,683 in 2019.

[363] $115.20 month/31 days=$3.72 per day. $3.72/12 hours=$0.31 per hour

[364] "Bureau of Aeronautics Average Unit Contract Prices - Navy Airplanes."

[365] Bureau of Ships, "U.S.S. Essex-Design Of."

[366] "Operational Experience of Fast Carrier Task Forces in World War II," 12.

impact on supplies and is another reasonable explanation in the reduction of spare parts ordered with the newer F6F fighters. The last four contracts written on the F6F included a spare parts percentage of sixteen, ten, nine, and eleven, respectively. All of these contracts were written after 29 December 1943. The last four contracts for the F4—written years earlier, between November 1940 and June 1942—included spare parts percentages of 15, 28, 30, and 30.[367] The mindset of the acquisition professionals at BuAer during the first two years of the war must have envisioned a shift in the methods of naval aviation maintenance once they realized the potential of carrier warfare. Not until after the Guadalcanal Campaign and the introduction of the F6F does the navy begin lowering the spare parts percentages on fighter contracts. At the same time, aircraft deliveries increased exponentially (see Table 6-3). Therefore, if funding was not a serious concern, as it seemed not to be by the middle of the war, why not spend less on spare parts and more on completely new airplanes and keep readiness at a consistently high level?

As previously stated, the biggest change in enlisted aviation personnel occurred between June and December 1942. The number of available technicians to the Fleet increased sharply over the next two years. President Roosevelt had called for an increase of 15,000 planes in the naval air fleet and eventually moved the target to 30,000 after the U.S. entered the war. Authorizations for more airframes went up throughout the war, and by 1945 the navy had accepted just over 71,500 new aircraft.[368] BuAer planners such as LCDR Wheelock saw the need coming for more aircraft technicians than the navy had ever employed before and accordingly reworked the technical training program to meet

[367] Bureau of Aeronautics, "Analysis of Naval Airframe Production Contracts."
[368] "Annual Report of the Secretary of Navy: Fiscal Year 1945," A-48.

such a demand. Thus, it is apparent that the navy did its best not to put the proverbial "cart before the horse." This should not be a shock to the casual observer. Surprisingly, most naval historians to date have neglected to recognize this, nor have any seriously commented on the importance of aircraft maintenance in terms of the development of carrier warfare.

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During the war, the annual budget for naval aviation was comparable to that of the Bureau of Ships (BuShip) and the Bureau of Ordnance (BuOrd). In total, BuShip had the largest authorization from Congress with $40.2 billion between July 1940 and August 1945. BuAer was authorized $26.1 billion, and BuOrd $23.1 billion. Of these authorizations, each Bureau only allocated and spent a portion of the funds. BuShip appropriated $38 billion but only expended $30.6 billion of that. BuAer appropriated $23.9 billion but only spent $15.7 billion. BuOrd came in with $22.6 and $13.8, respectively.[369] These figures show that for each Bureau, funding was not a significant problem.

Funding was practically unlimited for the navy during the war. It did not matter how many or how much, the navy got what it asked for. The only limit was that of productive capacity. Contracts and deliveries were limited by civilian production lines, not fiscal restraints. Actual labor costs for the navy to repair damaged aircraft might not have amounted to much, but the time it took to do so was priceless. Therefore, it made sense, in terms of combat readiness, to replace the inoperable plane as quick as possible

[369] "Annual Report of the Secretary of Navy: Fiscal Year 1945," 6–7.

with an operable one. It is worth noting the dramatic change in the navy's culture in this regard compared to the restricted budgets of the early to mid-interwar years.

Another way to analyze this is to look at the overall cost of equipping a carrier at different points in history. As we know, early carrier aviation had relatively fewer technicians available to the Fleet, but a much smaller number of carriers and aircraft as well.

Table 6-4: Cost of Equipping a Carrier Air Group, 1929 and 1944.[370]

1929 *Saratoga*	**Without Spare Parts**		**With Spare Parts**	
Type Aircraft	**Unit cost**	**Total**	**Unit cost**	**Total**
(36) F4B	$13,830	$497,880	$33,856	$1,218,816
(12) 02U	$13,180	$158,160	$47,053	$564,636
(32) T4M	$19,739	$631,648	$54,595	$1,747,040
Total (80)		$1,287,688		$3,530,492
1944 *Essex*				
(36) F6F	$87,209	$3,139,524	$129,841	$4,674,276
(36) SB2C	$106,393	$3,830,148	$158,894	$5,729,184
(18) TBF	$105,710	$1,902,780	$156,699	$2,820,882
Total (90)		$8,872,452		$13,215,042

[370] "Cost of Equipping a Carrier Air Group," n.d., Carriers Collection, Aviation, Box 13, NHHC.

Thus, the cost to supply a carrier air group with complete sets of spares and associated spare parts increased by 375% in fifteen years. Outfitting a carrier without spares and spare parts was dramatically cheaper, but the cost still inflated by nearly 400% during the same period. Even though the cost per aircraft and the cost of spare parts drastically increased, the nearly $10 million rise in spare parts per air group cannot be taken lightly. If that money were put aside and spent on new F6F fighters instead of spare parts, the navy would have had over 100 new F6Fs to send to the Fleet instead of parts that required down-time for the squadrons. This would positively affect the readiness and availability of the air group to carry out its assigned missions. During the war, mission-ready aircraft mattered most. Maintenance and repair were suitable for peacetime, but in war, fleet commanders needed their assets ready for combat, not awaiting maintenance.

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In 1944, a board headed by RADM Arthur Radford, known as the Radford Board, submitted its findings on the nature of present-day aviation planning and recommendations for forecasting as the war moved into its latter stages. Radford's findings also considered

peacetime aviation operation for postwar consideration. Based on the board's findings, the navy developed a plan that was designed to improve the overall maintenance and supply program for naval aviation as well as modify maintenance practices at sea. What became known as the Integrated Aeronautic Maintenance, Materiel and Supply Program (IAMMSP) relegated major repair and overhaul of naval aircraft to the Continental United States. It also provided for replacements of completely new aircraft rather than the

return of renovated aircraft to combat areas.[371] More simply, the plan ensured new aircraft were assigned to combat units. Those that needed reconditioning or major overhaul were sent back to the United States for repair and reassignment to training commands as necessary. In general, aircraft were retired from operational service after two combat tours to save on costly maintenance at sea and ashore.[372] This practice reduced the work load not only on the carrier aircraft maintenance departments but also on the CASUs and the AROUs operating in the Pacific. New aircraft required little more than routine maintenance to keep in the air. Thus, the service units could focus on the routine overhaul maintenance and minor battle damage repairs, rather than struggling to keep up with the "normal wear from hard use" in combat.[373] It made sense fiscally and in terms of how much would be required from the navy's labor force.

Once Radford's IAMMSP was in place, there was no longer a need to keep as many aircraft spare parts on the carriers. This allowed more space in the hangar for airplanes, which had a ripple effect. Additionally, by 1944, aircraft and aircraft carrier production were at their peak. More airplanes and aircraft carriers were available, and air groups were provided replacement planes on a regular basis. And since the Maintenance Department did not have to hold as much in the way of spare parts as previously, the hangar had more space available … for additional aircraft. Therefore, by reducing the footprint of spares and spare parts aboard the carrier, the navy could replace it with additional squadrons and aircraft. I believe that the changes in maintenance policy and procedures after 1943, particularly those associated with the IAMMSP, contributed

[371] Buchanan, *The Navy's Air War*, 354–55.
[372] "Chronology of Naval Aviation (Draft Copy)," August 18, 1960, NAVAIR Collection, Box 129, NHHC.
[373] Buchanan, *The Navy's Air War*, 355.

directly to an increase in the overall complement of aircraft per air group, in addition to aircraft and aircraft carrier modifications.

The percentage of spare or reserve aircraft incorporated into the design of each aircraft carrier varied over years and affected the size of the air group. The *Ranger* (1934) was designed to carry a margin of only 10 percent (8 spares) in addition to its operational 75 aircraft.[374] Plans for the *Wasp* (1939) called for a 50 percent reserve of a similar complement of 75 aircraft.[375] According to the initial design requirements of the *Essex*-class carrier, the navy had built the ship (CV-9) to sail with the capacity for stowage of "50 percent of complement aircraft, as spares, disassembled" similar to that of the *Wasp*.[376] In 1940, that equated to space for approximately forty airplanes disassembled in the hangar, based on the original plan for eighty-four aircraft per air group. By 1943, newer *Essex*-class carriers like the *Yorktown* (CV-10) operated with the equivalent of just 25 percent of its total aircraft strength stowed in the hangar spaces.[377] That meant a more powerful striking force in flyable aircraft. Therefore, the diminishing percentage of reserve aircraft per carrier resulted in a larger-sized air groups, eventually culminating in 100 plus airplanes per carrier. These fluctuations served as an indication of peace and wartime influences on navy planners. Forthcoming changes in maintenance policy regarding the decision to replace more damaged aircraft rather than repairing them, would be a factor in determining the number of spare airplanes on board.

After Pearl Harbor, it became essential that BuAer keep the Secretary of the Navy up to date on aviation requirements in support of the war effort, especially after the fiscal

[374] Friedman, *U.S. Aircraft Carriers*, 87.
[375] Ibid., 111.
[376] Bureau of Ships, "U.S.S. Essex-Design Of."
[377] David A. Anderton, *Hellcat* (New York: Crown Publishers, 1981), 16.

year estimates were submitted months or years ahead of time. As operations dictated, the specific requirements were extremely dynamic. BuAer revised its estimates on an "as-needed" basis in response to combat losses and updated ship completion estimates in a "Summary of Objectives" document. As of 31 October 1942, BuAer had determined that the proper percentage of spare combatant aircraft was 33.3% of the total air group.[378] In terms of a CV air group, this meant that for every three aircraft assigned to a carrier, a single "ready" spare was required. This did not necessitate the CV carrying an extra three dozen aircraft, but BuAer ensured that all parties were aware of the large quantities of "extra" airplanes that would need to be purchased over the course of the war to meet this requirement.

The numbers do, however, line up nicely with the later configurations of the *Essex*-class air groups, which by August 1944 were listed as embarking ninety-six aircraft, and by June 1945 embarking with 102 to 103.[379] While not exactly a 33.3% addition to the original eighty-three plane configuration, it certainly explains the ability and reasoning behind increasing the complement of airplanes. If BuAer believed that approximately one-third of its combat planes would need replacement during the war--and understanding the nature of logistical challenges of getting new planes to an aircraft carrier in the middle of the Pacific--why not deploy with as many of the extra planes already on board? Rather than toiling with repairs or aircraft deliveries, the navy simply reconfigured the *Essex* air groups to meet the requirements of carrier warfare.

[378] "Bureau of Aeronautics: Summary of Objectives as of 10-31-42," October 31, 1942, RG 72, Entry 67, Stack 470, Row 63, Box 189, NARA II.
[379] Friedman, *USS Yorktown (CV-10)*, 20.

The aggregate numbers of late 1944 deliver an even more replacement-minded view of carrier aviation. According to the briefing given on the overall state of naval aviation on 5 July 1944, the percentage of spares that were to be made available to carrier air groups was even bigger than the 33.3% mentioned a year before. As discussed early, sixteen replacement planes per month were required on average for an *Essex*-class carrier air group. Table 6-5 is a reproduction of BuAer's Production Planning Division's projected requirements for all carriers at sea or in production of 1944.

Table 6-5: Aircraft Distribution for Carriers, June 1944.[380]

Type Ship	Ships to be commissioned by 12/31/45	No. Units	Planes per Unit	Total Operating	Spares	Total
Heavy Carrier (CVB)	2	5	121	605	412	1017
Medium Carrier (CV)	23	43	91	3913	2666	6579
Light Carrier (CVL)	9	19	33	627	427	1054
Escort Carrier (CVE) - *Sangamon*	21	38	33	1254	854	2108
Escort Carrier (CVE)-*Kaiser* & *C3*	62	61	24	1464	997	2461
Night Fighter Groups (Shipboard)	0	28	12	336	229	565
Miscellaneous		1	117	117	80	197

Clearly, the impact that spare aircraft had on fleet operations was significant. By June 1944, most carrier groups were allocated a contingent of spare planes that accounted for

[380] "The Program for Naval Aviation."

approximately 40 percent of the total of all aircraft assigned (see Table 6-5). This meant that for every ten operable airplanes on the carrier's flight deck, four more were ready spares located in either in the hangar or prepositioned at a CASU or naval air station.

By 1944 naval war planners had apparently accepted that the Pacific air war would be one of attrition. Aircraft in repair would do little to support combat operations, but rapid replacement of damaged or malfunctioning airplanes would. One should not interpret this as a lack of confidence in the navy's aircraft maintenance program, but rather in response to the nature of the war. The vast distances in which the carrier task forces were operating made logistics to and from the continental U.S. very difficult. The time and expense of shipping damaged airplanes back to the West coast of the United States, or even Pearl Harbor, was impracticable. The navy could not afford to wait weeks at a time for replacement parts or aircraft while amphibious forces were fighting their way through Japanese-held island chains throughout the South Pacific.

The air group had to defend the task force, support the ground units fighting through the islands, or strike enemy combatants from above. It was the job of the maintenance division aboard the carrier to keep planes in the air. Aircraft losses were common throughout the war, as one would expect due to the frequency of operations and the ferocity of Japanese resistance. However, aircraft losses due to reasons other-than-combat were also quite high—in fact even more than combat-related losses. While the specifics of what constituted an operational loss is not defined, one can reasonably associate it with both mechanical failure and pilot error. (See Table 6-6)

Table 6-6: U.S. Carrier Aircraft Losses in Combat and Non-Combat Operations[381]

Cause of loss	No. VF (Fighter)	% VF	No. VB/VT (Attack)	%VB/VT
Enemy Action	1463	36.1	1025	37.7
Combat not Enemy Action	30	0.7	30	1.1
Friendly Fire	128	3.1	91	3.2
Operational Accidents	2390	58.9	1547	56.8
Other	45	1.2	30	1.2
Total	4056	100	2723	100

The number of operational losses is staggering in both fighter and attack aircraft. Even when adding all other types of losses, operational losses still outweigh all other losses by a ratio of nearly two to one.[382] Within these statistics, one can infer that the biggest threat to U. S. Navy pilots was not the Japanese Navy, but rather themselves and their own aircraft. But how much of that can be attributed to faulty aircraft systems, unsatisfactory maintenance, or in-flight errors by the pilots?

Exact answers to such questions are elusive, but looking even closer at the postwar analysis of the Fast Carrier Task Forces, it is apparent that within combat situations the navy did delineate one cause of loss from the next. Over the course of the war, diligent records were kept for aircraft losses that occurred while the carrier task forces were engaged in combat missions. Surprisingly, within that subset, losses caused by enemy action and operational loss are almost identical.[383] From December 1941

[381] "Operational Experience of Fast Carrier Task Forces in World War II," 72.
[382] Total operational accidents: 3937, All others: 2392. Data extracted from table 6-6.
[383] Combat missions is a loosely defined term. For reporting purposes, Navy aircraft could (and still can) sortie in support of a combat mission without seeing any actual combat, i.e., the no enemy forces are located or engaged. Any flight launched with the possibility of encountering enemy forces (air, sea, or land -based) would be considered a combat mission whether or not contact was made. Flights where the intended purpose was for training, proficiency, logistical support, or post-maintenance check flights would constitute non-combat sorties and be notated as such in aircraft and pilot log books. During WWII, naval

through August 1945, the carrier-based VF community lost 1078 airplanes to enemy action and the attack aircraft (VB/VT) losses of the same sort numbered 756. During that same period, operational losses which occurred during carrier-based combat missions numbered 1,221 for VF and 656 for VB/VT aircraft. (See Table 6-7)

Table 6-7: Losses by Carrier Aircraft on Combat Mission by Cause of Loss[384]

Cause of Loss	**VF**	**VT/VB**
Enemy Actions:		
Aircraft	302	107
Ship	84	183
Land Anti-Air	691	457
Other	1	4
Enemy Action Total	1078	756
Operational Losses:		
Mechanical Failure	354	173
Pilot Failure	440	137
Fuel Exhaustion	114	167
Other	308	179
Operational Total	1221	656

aviators first began notating flight time in support of combat in their logbooks with green ink. Since then, combat missions are routinely referred to as "green time" in aviator jargon.

[384] "Operational Experience of Fast Carrier Task Forces in World War II," 74. Statistics herein are subject to 10% margin of error according to the document (p. 75)

The total number of enemy-induced and operational losses are 1,834 and 1,877, respectively. But aside from land-based anti-aircraft guns, the biggest threats to USN carrier aircraft was, first, pilot error (577), then mechanical failure (527), and lastly the elusive "other" category (487). Enemy aircraft followed behind all of these with 487 losses attributed.

Carrier aviation maintenance only had a stake in one or perhaps two (depending on what "other" entailed) of these causes. The better that the technician did his job on the flight deck, the less chance there would be of mechanical failure. However, considering the *replace* versus *repair* culture at the time, it is quite possible that the influences of later maintenance policies such as the IAMMSP may have affected these numbers.

Until 1944, carrier operational losses due to mechanical failure were extremely low. 1942 reported only sixteen and 1943 only twenty-eight. In 1944, the number jumped to 199 and then in eight months of fighting in 1945 mechanical losses numbered 284.[385] The number of sorties, aircraft, and aircraft carriers were much lower in 1942-1943 than in 1944 and 1945. However, the introduction of the IAMMSP into the navy's aviation maintenance practices in the second half of 1944 was conveniently situated at point where the rates of loss are at their height.[386]

Understanding the impact that revised maintenance procedures and committing newer aircraft to the Fleet on a regular basis during the second half of the war is best seen in what was termed aircraft "availability." This number differed from the aircraft aboard, usually a few short. Unavailable, or "down" aircraft due to repair or routine maintenance

[385] "Operational Experience of Fast Carrier Task Forces in World War II," 74. Data includes both fighter and attack model aircraft (VF, VT/VB)
[386] "Operational Experience of Fast Carrier Task Forces in World War II," 74.

counted against readiness percentages. It was the job of the carrier's maintenance team to have as many available aircraft as possible when needed. The goal would be to have maximum aircraft availability during periods of sustained combat operations.

There is archival evidence to support the argument that the revised maintenance policies after 1943 had a positive impact on aircraft availability when the navy needed it most. From April to June 1945, Carrier Division 22, consisting of four CVEs, reported that its average availability of VF airplanes was 88% or 69 out of a 78-airplane compliment. The Torpedo-bomber models (VT) averaged 43 of 47 available, equating to 91% in support of the occupation of Okinawa. The division averaged a striking force of 78 fighters and 47 attack aircraft divided amongst four escort carriers. Of those, an average of 69 fighters and 43 torpedo bombers were available for combat. When data from two additional carriers attached to the division on a temporary basis is included with the reporting, 26 of the 30 aircraft on hand were combat ready on a daily basis. The average number of airplanes on board each CVE in the division was 29.5 and the average number available was 25.9. This equated to an overall availability of 87.8%, which is representative of the last two years of the war.[387]

From 10-16 January 1945, Task Force 38, which consisted of the *Hornet, Lexington,* and *Hancock* battle groups, conducted combat operations in the South China Sea with an initial complement of 942 aircraft. On day one of combat operations, Task Force 38 reported 850 of 942 (90%) aircraft available. This included 607 of the 657 fighters assigned to the three air groups. By the end of the operation, availability had

[387] Commander, Carrier Division Twenty-Two, "Report of Capture of Okinawa Gunto, Phases I and II, 27 March to 19 June 1945," July 20, 1945, RG 38 "World War II War Diaries," NARA II, https://www.fold3.com/image/1/296526823.

dropped to 81% due to combat losses only.[388] The IAMMSP was fully integrated into the Fast Carrier Task Forces by 1945 and it enabled carrier groups to keep its availability percentages in the 80-90 percentile for the duration of the war.[389]

As we have seen, the navy began replacing worn out aircraft with brand new ones in earnest by 1944. Simultaneously, the naval aviation's labor force, the enlisted aviation technician, reached its peak strength. Carrier production was also peaking at the same time. Fiscally, the navy had the funds to supply each air group with new planes at the rate of sixteen per month.[390] Technicians were filling these billets within the carrier aircraft maintenance divisions as well as the CASUs and AROUs. Overhauls were at peak production during around the same time. Once the Radford Board submitted its recommendations for a new maintenance policy that argued for a better system than had been in place the previous two years, why wouldn't the navy embrace it? Perhaps it was Radford's reputation as a previous Director of Aviation Training for the CNO in 1941, or his experience as a Carrier Division Commander in 1943, or his tenure as a Carrier Task Force Commander in 1944—one can only surmise. What is apparent however, is that the navy embraced his aircraft maintenance policy recommendations wholeheartedly. I cannot simply say that naval aviation maintenance embraced a "throw away" culture solely based on Admiral Radford's recommendations, but as we have seen, there is ample

[388] Commander, Air Force Pacific Fleet, "Analysis of Air Operations: Fast Carrier Operations in the China Sea, 10-16 January 1945," April 2, 1945, 4,12, RG 38 "World War II War Diaries," NARA II, https://www.fold3.com/image/1/295415402.
[389] In comparison, the U.S. Army Air Corps reported much lower rates of available aircraft during the War. The 43rd Bombardment Group reported that no more than 50% of aircraft assigned were available for missions in the Southern Pacific theater in 1942. Much of their shortcomings were due to "shortages of spare parts, trained mechanics, and service units." See Wesley Frank Craven and James Lea Cate, eds., *The Army Air Forces in World War II: The Pacific: Guadalcanal to Saipan, August 1942 To July 1944*, vol. 4 (Chicago, IL: The University of Chicago Press, 1955), 9.
[390] "The Program for Naval Aviation."

evidence that such a mindset did exist in some degree from 1944 onward. "Keep 'em flying" might have been the motto of the navy's aviation maintenance departments, but perhaps that really only applied to six to twelve month "old" aircraft? More realistically, in order to keep even the newer airplanes available, the need for non-emergent daily maintenance on board carriers was so great that aircraft technicians were fully utilized, even in a "throw away" culture.

Ultimately, it was the aircraft technician who kept the navy's carrier aircraft in the air when needed most. There was a shift midway through the war in numbers of available aircraft, spare parts, and technicians. As if it was planned, even though it was not, numbers of new planes and personnel went up and percentages of spare parts went down. Policy changes within the institution adapted to the needs and available assets of the time. The role of naval aircraft technicians might have changed between 1940 and 1945, but nevertheless, they remained an integral part of the navy's success in the Pacific Air War. Bob Hope best summed up the importance of the naval aircraft technician in the War when he said:

> You know it takes more than good airplanes to make an aircraft carrier or a Naval Station and more than a good pilot to get a plane over the target and bring it back home safely; it takes men behind the pilot. Men trained in Radio. Mechanics who are able to man a machine gun or make repairs in mid-air. Machinists Mates back on the carrier or on the ground to repair the latest motors, Metalsmiths to sew up those broken wings. Ordnancemen to make sure that a plane's guns will always bark at the right time… And when these men come out of this training center, they're ready to do all this and more, ready to pitch and play third base on the Navy's major league team of air and ground crewman. Yes, sir, folks, when you think of General MacArthur's famous words 'I'll Return,' add a word of

thanks to fellows like these who helped make it possible for him to say, 'I have returned!' [391]

[391] "Bob Hope's Tribute to Aircrewman," *The Bluejacket*, February 8, 1945, Vol 3, No.11 edition, Aviation Commands '41-'52, NATTC Memphis, Box 240, NHHC.

Chapter 7: Conclusion

Until now, an in-depth analysis of naval aircraft maintenance as part of the complex institutional history of World War II has been absent from the canon of twentieth-century naval history. The defeat of the Japanese Navy in the Pacific came largely from the decks of the U.S. Navy's Fast Carrier Task Forces. Advances in technology no doubt played a pivotal role, however, without concomitant achievements in technical education, labor methodology, and logistical innovation, victory at the very least would have been delayed. The ability of the navy to provide the requisite number of trained aircraft technicians and supply the U.S. Fleet with enough materiel to achieve its strategic objective was integral to its success. The war between the world's two largest aircraft carrier fleets and ultimately the navy's ability to project power cannot be fully comprehended without identifying the critical role of the aircraft technician. Recognizing the complete picture from the outset of aviation technical schooling to the everyday challenges that carrier-aircraft technicians faced at sea throughout the war is an important contribution to the historiography of the U.S. Navy in World War II.

The narrative behind the U.S. Navy's development of a large technical workforce in order to support a new era of carrier warfare is a complex history of institutional change. No longer was the striking power of a navy limited by the range of a battleship's guns. Carrier based aircraft could travel several hundred miles further and deliver more ordnance than any shipboard naval gun. By the end of the 1930s, it was evident to some that the potential striking power of the aircraft carrier would eventually supersede the notion that its principal contribution to the to the fleet would be as auxiliary force to the

battleship and surface navy. Yet, it seemed as if no one in naval leadership fully understood the ramifications of building a new navy around the aircraft carrier.

The ability of the United States Navy to fight a protracted war throughout the Pacific Ocean was not solely the result of technology, tactics, or admiralship. Naval aviation maintenance played a major role in the U.S. victory and indeed constitutes a significant historical subject. In order to better understand the full dimensions of modern naval war in the age of the aircraft carrier, it is essential to consider all elements of the military institution, not just those that made headlines. As of this writing, World War II naval historiography is practically devoid of critical comprehensive discussion of naval aviation maintenance.

In order to understand the institutional changes that took place within the United States Navy during the Second World War, it is essential to ask the right questions. It is common knowledge that there was an immense buildup of people, planes, and ships, but how was that sustained operationally? More specifically, how did the naval aviation transform thousands of new and often untrained recruits into an effective force of skilled technicians? In doing so, how did the character of this achievement affect the conduct of operations? To what degree did the navy's success creating a new technical workforce change its culture?

Naval aviation leadership throughout the interwar period focused on the improvement of technology and tactics rather than training a new, and in the event of war, necessarily large cohort of enlisted personnel. Aircraft maintenance was an afterthought for much of the era because of the small number of carriers and aircraft. Until 1939, aircraft maintenance did not garner much attention, for it had always been

sufficient. Yes, there was some grumbling about not having enough personnel, but nothing serious enough to warrant any real change. However, when the United States realized a two-ocean naval war was imminent and a drastic increase in the size of its aviation fleet was ordered, the navy was forced to reconsider its earlier practices and forge new polices and processes.

First, the Bureau of Aeronautics had to revise its personnel and technical training policies in order to manage the colossal buildup of personnel and planes. Recruiting individuals with technical acumen and the activation of Naval Reserve personnel with maintenance experience became a high priority. The Bureau modified its internal administrative structure in order to manage the rapid influx of recruits and transform them into competent aviation mechanics.

In addition, the incoming recruits had to be trained how to maintain naval aircraft. Technical trade schools were built, a curriculum for different aircraft systems was developed, and field experts were brought in to produce academic material. Standardizing curriculum and filling classrooms with qualified instructors was a challenge. By 1941, the schools were managing to graduate a satisfactory number of candidates, but the increasing burden of the administrative and logistical requirements became too much for BuAer.

The navy's bureaucracy had to restructure in order to best accommodate the complex training requirements. Consolidating all technical schools under an independent command was the adjustment that naval aviation needed. The Naval Aviation Technical Training Command (NATTC) took control of all technical training in 1942 and never looked back. Formalized vocational training was established at major naval installations

throughout the United States. Additionally, various levels of technician training were made available to enlisted men and women based on their proficiency and experience. Periods of instruction were streamlined so the trade schools could deliver more aviation technicians at a faster rate. Specialized ratings and qualifications were also added to sailor's service records so supervisory personnel could place each technician into a job where he or she would be most productive once they were assigned to a maintenance unit.

The structure of naval operational maintenance programs also required modification. At sea, aircraft maintenance on the carrier transitioned to a full-time, integrated work force. Enlisted aviation technicians were fully integrated as permanent members of the ship's crew. The aircraft maintenance division on board the carrier no longer belonged to the air group, but were now a full-time component of the ship's air department. The more training that technicians received while assigned to technical training commands (trade schools), the more the carrier's maintenance team could specialize its work force.

Specialization of labor within the work force was critical to the efficiency of overhaul and repair facilities on and off the carrier. Most overhauls and major repairs were completed at shore establishments where the specialized technicians were readily available. Many technicians received advanced training on specific mechanical and electrical aircraft systems in addition to the general knowledge gained from A schools. These experts soon permitted the maintenance department to minimize aircraft system troubleshooting and repair time. Specialization with the carrier's air department reduced aircraft "down" time because minor problems could be corrected on the spot, and

airplanes could be placed back onto the flight schedule. If the repair was more labor-intensive, it was completed at a shore-based facility somewhere in the Pacific island chains-at either a Carrier Aircraft Service Unit (CASU) or an Aviation Repair and Overhaul Unit (AROU).

In developing the forward-deployed servicing and overhaul units, the navy was implementing a division of labor on the macro-level. Carrier maintenance was no longer required to complete the intensive labor associated with overhaul and major repair. Task forces were deployed to fight, not to fix. Therefore, they could delegate the labor-intensive overhaul work to the CASU and AROU units and focus on having available aircraft for each day's flight schedule.

The division of labor concept, exemplified by the CASU and AROU model was a breakthrough in the naval war against Japan. By 1944, the aviation navy had developed its skilled labor forces to levels sufficient to fill the personnel needs of both the carrier task forces and shore-based overhaul units. Simultaneously, the war industry reached its highest levels of production of naval aircraft and aircraft carriers. Admirals and aircrew had the latest technology, and lots of it. Fully trained technicians did "keep 'em flying," which allowed aircrew and admirals to utilize their weapons to the maximum extent possible.

The commercial aircraft industry's massive production of naval aircraft solved many of the supply problems that plagued carrier aviation early in the war. In doing so, however, it also altered the culture of aviation maintenance that had been in existence since the 1920s. Prior to 1944, aircraft technicians did their best to minimize aircraft losses and down time due to mechanical or structural malfunctions that could be repaired.

Often this meant an aircraft would be unavailable for the flight schedule for an extended period. After 1944, the Integrated Aeronautic Maintenance, Materiel and Supply Program (IAMMSP) further changed the how the navy conducted its aircraft maintenance.

When the IAMMSP was introduced into the navy's aviation maintenance departments, it had an immediate and lasting effect on the culture of aviation supply and maintenance. The IAMMSP directed that major overhaul and repair would only be conducted in continental U.S. facilities. CASUs and AROUs would be dedicated to supporting the forward deployed carrier air groups. Broken or malfunctioning aircraft were no longer the problem of the carrier air departments, CASUs, or AROUs. Most importantly, the IAMMSP dictated that combat aircraft would be retired after serving two deployments in support of combat operations and replaced with new airplanes from the factories. Prior to 1944, the expectation was that carrier aircraft would serve as many as five years in operation before replacement. The culture within naval aviation maintenance shifted from one of repair to one of replace.

Some might define this as a "throw away" culture, which has a negative, materialistic connotation about it. However, this was the best course of action based on the protracted war of attrition that the navy was engaged in. Repair consumed valuable man-hours and placed the air group at a disadvantage. Having a "down" aircraft meant one less bomb on target, or the possibility of Japanese bombers finding their way to the U.S. carriers. Carrier technicians were best trained in routine servicing and minor repair on board the carriers. The problem of supply and logistics was remedied through various means, particularly the CASU and AROUs. The navy implemented a plan to deliver sixteen new airplanes per month to each air group. This accounted for aged out planes

and those damaged or lost in combat. It also relieved the pressure on aircraft technicians at sea by minimizing the extra workload that older aircraft often required. The culture that many longstanding professionals among the enlisted ranks of aircraft maintainers had grown accustomed to was a product of a fiscally conservative era of peace. 1941-1945 was very different, and the navy was compelled to adapt accordingly.

Ultimately, the air groups of the Fast Carrier Task Forces completed their task in defeating the Japanese Navy. Aircraft availability averaged between 80 and 90 percent throughout the latter half of the war. Task Group Commanders were supplied the appropriate number of "up" aircraft when necessary. Aircrew had planes to fly and bombs to drop. The aircraft technician on the flight deck and in the hangar was proficient and rarely short of work. Even without the burden of overhaul and major repair, aircraft maintenance on the carrier was non-stop. Daily maintenance and servicing of aircraft was time consuming and critical to the success of each strike made by each task force. The Naval Air Technical Training Command referred to World War II as "The Technicians War."[392] While this was most likely intended as a motivational slogan, it was not far from the truth.

Some of the changes in naval aircraft maintenance practice had lasting effects. For one, this period is responsible for establishing many of the naval aviation maintenance policies and procedures currently in existence. Specialization and division of labor is commonplace in the navy's enlisted workforce. The maintenance department is still divided into work centers identified by their ratings. The number of ratings

[392] Headquarters, Naval Air Technical Training Command, *Technicians' War: A Picture Story of U.S. Naval Air Technical Training Command*.

available to enlisted men and women have been reduced, but the opportunity to seek specialized qualifications in many technical fields still exists.[393]

Maintenance procedures that came into existence during the Second World War continue to be a part of naval aviation. The battle against corrosion is still being fought. Derivatives of the liquid preservative compounds that were used to protect metal aircraft parts in WWII are in use on naval aircraft today. Corrosive-inhibiting agents as are commonplace in every U.S. Navy squadron.[394]

This study underscores the importance of education in the process of creating an effective modern military. The Bureau of Aeronautics made the hard decision to embrace change in order to meet the needs of the Fleet. Educating aircraft technicians in the same methods that had been done for years would not suffice for what was recognized to be imminent war. Navies today (and the military overall) rely on technology to fight wars more than ever. It is not enough to simply sign young men and women up at the recruiting stations. It takes a vast network of internal organizations to bring that new recruit through basic training, then A school, and follow-on schools if able. The trailblazing efforts of Austin Wheelock, Daniel Brimm, A.C. Read, Arthur Radford in relation to the technical training programs of the aviation navy have gone largely unnoticed. If one examines the structure of the U.S. Navy's aviation technical training today, little has changed little since 1943.

In a broader context of the war, my research has emphasized the lack of preparedness throughout the U.S. Navy until 1943. My conclusions are similar to David

[393] For additional details on the current naval aviation maintenance program, see COMNAVAIRFORINST 4790.2 series publication, "The Naval Aviation Maintenance Program (NAMP)."
[394] Ibid.

Glantz's argument in *Stumbling Colossus*.[395] Even with a strong industrial and personnel base in 1939, the Soviet Union lacked a highly trained, well organized, and skilled labor force that could match the Nazi war machine. Likewise, the U.S. Navy had a strengthening industrial base in ship and aircraft production, but for the first two years of the war, they lacked the skilled labor necessary to sustain a protracted carrier war in the Pacific. This was evidenced by the large quantities of aircraft engine overhauls that were backlogged by the second half of 1943, the limited number of combat flight hours flown before 1944, and the great swell of technical ratings into the fleet after the first year of war. My argument does not discount the impact that the Fast Carrier Task Forces of 1944-45 had on the outcome of the War. However, it was the introduction of a specialized workforce and the skilled technicians who labored on the hangar decks that constituted the final piece of the puzzle, the missing link in WWII naval historiography.

This history of naval aviation maintenance is uncharted territory. Much work in this field is needed. The "battle piece" has been largely exhausted, but the narrative of "machines, men, manufacturing, management, and money" in light of World War II naval aviation maintenance is wide open for further exploration. My hope is that my findings will challenge other historians to look below the flight deck, outside of the cockpit, and inside the trade schools to further enhance our rich history of World War II naval aviation.

The study of WWII carrier maintenance should also encourage questions outside the limits of naval aviation and carrier warfare. There is much to be said about the nature of sustaining labor and capital in a protracted wartime environment based on the conflict

[395] David M. Glantz, *Stumbling Colossus: The Red Army on the Eve of World War*, (Lawrence, KS: The University of Kansas Press., 1998).

between Japan and the United States. The majority of recent wars have been over within a few months, or weeks. This is especially true when major combat units such as Carrier Strike Groups or Marine Expeditionary Forces are actively engaged with other large-scale organized military units.[396] What happens when one of the fighting continues past a few months and into years? Are protracted wars only a thing of the past? What lessons are there to learn from the unlimited spending that produced thousands of technologically advanced weapons, but did little to provide the skilled labor necessary to maintain such weapons. Are twenty-first century militaries prepared to obtain the skilled labor necessary to fight a multi-year war over large geographic distances? Perhaps this dissertation will encourage historians to research and analyze more topics such as the relationships between skilled labor, industry, and capital in modern protracted warfare. And in turn, our scholarship may prompt government and military policy makers to consider the hard lessons of the past.

[396] While the current war in Afghanistan is approaching two decades of conflict, I do not consider it a protracted war in the same sense that WWII was because of its irregular, insurgent nature. WWII in the Pacific was fought between formal nation-states with well organized, large conventional forces. Desert Storm would be a current example of a large-scale conflict that required little in the way of extended capital and skilled labor over time due to its brevity, very different than what the U.S. experienced in World War II.

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