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THE NEGLECT OF LONG–RANGE ESCORT DEVELOPMENT DURING THE INTERWAR YEARS (1918–1943)

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Preface

This project is part of a series of Air Command and Staff College, Class of 1997, research papers that discuss the development of American air power doctrine prior to World War II. This paper discusses the relationship between the development of air power doctrine and the development of long–range escorts for strategic bombardment in World War II.

I would like to express gratitude to my research advisor, Major Carl Baner, for his assistance. Additionally, I would like to thank Dr. William Suit and John Weber of the Air Force Materiel Command History Office for providing information for this project.

Abstract

America's lack of effective long–range escort for strategic bombardment was the Army Air Force's worst failure of World War II. The basic cause for peacetime negligence of long–range escort development was that air power decisions were influenced more by budget considerations and less by sound doctrine. This historical study uses a chronological approach to describe the evolution of long–range fighter escort.

Air power doctrine was driven by technical advances and consisted of untried theories. The advent of the all metal mono–plane gave credibility to the emerging doctrine of strategic bombardment. The Air Corps became polarized between bomber and pursuit advocates, where the dominate doctrine of employing self–protecting bomber formations devalued the role of long–range escort.

Money was viewed as the critical ingredient for building air power while doctrine was secondary. The desire to attain air power during an era of constrained budgets produced unhealthy competition between the Army and Navy. Restrictive budgets also required prioritization of research and development and production programs. Several efforts failed to produce multi–purpose aircraft that would also fulfill the escort role.

The Spanish Civil War experience proved the need for long–range escort. This late realization prompted the programs that eventually produced an effective long–range escort.

Chapter 1

Introduction

The story of the birth of military aviation during World War I is well documented, as is the amazingly rapid growth of aviation technology in the years leading up to World War II. During the interwar years the United States Army struggled to build its air arm, culminating in the great American air power successes in World War II.

Many brilliant, and often head strong, aviation heroes like Generals Billy Mitchell, Claire Chennault, Henry "Hap" Arnold, Benjamin Foulois, Lawrence Kuter, Haywood Hansell and Harold George, struggled to develop doctrine for American air power. The feats of these men are laudable in taking a fledgling air arm and making it a world class power. With more than half a century of hindsight, we can take a critical look at mistakes made in the development of air power doctrine. In particular, the development of the daylight strategic bombing doctrine, while vitally important to American success in World War II, failed to place air superiority as a tenet of air doctrine. The generally accepted idea was that invincible, self–protecting bomber formations would fight through all defenses and destroy targets in the enemy's heartland. In the early stages of World War II, this idea proved to be disastrous until the nation could hurriedly develop and produce long range escort fighters in quantities needed to defeat the Luftwaffe. "[Delays in] the eventual development of the long–range fighter [was], according to the official historians

of the Army Air Forces in World War II, 'the most serious flaw in the Army Air Forces' program.'"[1]

These historians were referring to the Army Air Forces' (AAF) first battle experiences with daylight strategic bombing in Europe, Operation Pointblank against German industrial targets. By the summer of 1943, foreign bombardment experience had shown Army leadership the desirability of fighter escort. P–38 Lightning and P–47 Thunderbolt fighters had been hurriedly fitted with dropable external fuel tanks to extend their range. The extended range allowed these fighters to escort the American bombers as far as the German western frontier. However, the Luftwaffe attacked bomber formations while they were enroute to their targets. This forced the fighters to release their drop tanks early in order to gain maneuverability, but in so doing eliminated the fighters' usefulness as escorts for the remainder of the mission. In July 1943, 132 B–17 bombers were lost with their crews. In August, 60 out of 376 bombers did not return from missions against the ball bearing industry at Schweinfurt and the Messerschmitt aircraft factory at Regensburg. In October, 148 bombers were lost in reattacks on Schweinfurt and other cities.[2] These horrible losses generated emergency efforts, during the war, to develop suitable long range escort fighters and a doctrine for their use.

Thesis Statement

This paper examines why the Army Air Corps neglected the development of long–range fighter escorts until World War II when the need for such aircraft became desperate. The basic cause for peacetime negligence of long–range escort development was that air

power decisions were influenced more by budget considerations and less by sound doctrine.

The paper discusses several tensions that existed during the interwar years that affected the development of long range escort fighters. The 1920s and early 1930s were difficult times for military budgets. The Army air arm had to compete with Army ground forces for funds, while the Army and Navy fought over roles and funding. There were also disagreements over whether to concentrate on technological advances or on quantity production of aircraft and conflicts over priorities of research and development programs. Meanwhile, air power doctrine became focused on strategic bombardment that, to a great extent, discounted the usefulness of pursuit aviation.[3] All of these tensions contributed to United States entering World War II without an adequate long–range escort fighter.

Scope

This paper focuses on the Army's development of long–range escort fighters. Examples of bombardment aviation are included to highlight the controversies between bombardment and pursuit doctrine. Transport, observation, and attack aviation development programs are not discussed because they are viewed as less controversial branches of military aviation. Naval aviation is discussed only to show competition over roles and funding.

The paper uses a chronological approach to describe the evolution of long–range fighter escort. The chapters discuss three epochs: the end of World War I through the late 1920's, when the Army struggled to define the roles of air power; the late 1920's through the Munich crisis in 1938, when the doctrine of strategic bombardment was born;

and the time between the Munich Crisis and US entry into the European theater of World War II, when the Army struggled to develop long–range fighter escort. The conclusion chapter ties together the main points of the preceding chapters to support the thesis statement.

Notes

[1]McFarland, Stephen L. and Wesley Phillips Newton. *To Command the Sky: The Battle for Air Superiority Over Germany, 1942–1944*. Washington and London: Smithonian Institution Press, 1991, 103.

[2]Jackson, Robert. *Mustang the Operational Record*. Washington, D. C.: Smithsonian Institution Press, 1992, 32–33.

[3]There is no universal definition of what pursuit aviation entailed, however generally, it is considered to be the class of aircraft specifically designed to engage enemy aircraft in aerial combat. This class of aircraft included interceptors and escort fighters.

Chapter 2

The Struggle for Air Power in the 1920's

Pursuit Aviation Dominance

The US Army was beginning to learn about the full potentials of air power during the 1920's. Early in the decade, the Army, being commanded by ground force officers, continued to view the airplane as a tool to support ground troops. Its primary roles were observation and close air support. Pursuit aviation was also viewed as necessary to engage enemy air power as it had done in World War I. Aviation enthusiasts, such as Billy Mitchell, had a larger vision for air power. This view of air power advocated strategic bombardment of the enemy homeland as being decisive in winning wars. These air power advocates were a minority. Not only was the potential of air power an unknown quantity, but the state of technology in the 1920s certainly did not allow decisive strategic bombardment.

Throughout the 1920s, bombardment aircraft performance lagged that of pursuit aircraft. The rather large, wood and metal bi–plane bombers were underpowered for the bomb payloads they carried. In the mid–1920s the Materiel Division of the Army Air Corps urged industry to begin the development of 4 engine mono–plane bombers. However, the War Department overruled the Materiel Division's efforts, siting concerns

about high production and maintenance costs. In addition, the nation's research and development facilities were underfunded, and they lacked equipment to develop such a bomber.[1] It was not until 1930 that the Air Corps, at the urging of bomber enthusiasts, put out a circular requesting a heavy bomber design. This led to the B–10 bomber, a twin–engine, all metal mono–plane. This was the breakthrough design that made strategic bombardment seem possible.[2]

Meanwhile, pursuit aviation enjoyed a performance and flying qualities advantage over other types of military aviation; however, aviation development in the US lagged European development. Captain Claire Chennault, a leading advocate for pursuit aviation, lamented the state of American pursuit aviation in the years just following World War I.

> The First Group flew trim little French Spads and British SE–5's, painted with the stars and spangles the squadrons had made famous in combat over the Western Front. They were still flying foreign machines because, as late as 1921, the American aircraft industry had not yet produced a fighter that could equal either French, German, or British models.[3]

American pursuit aviation advanced rather rapidly throughout the decade. Within a few years American pursuit aircraft had advanced to a point where they were on par with rest of the world. The Curtiss PW–8 Hawk and the Boeing PW–9 were fast and maneuverable for their time.[4] (The characteristics of these and other pursuit aircraft are listed in Table 1.)

Although pursuit aviation advanced technologically in the 1920s, no clear doctrine emerged for the employment of pursuit. There was also no agreement on the roles of pursuit aviation or even on required characteristics of pursuit aircraft. Major Carl Spaatz, another pursuit aviation advocate, made an early attempt to clarify pursuit aviation in 1922. He identified four types of pursuit aircraft: offensive pursuit for air superiority;

defensive pursuit for escort duty; night pursuit for night fighting; and attack pursuit for both aerial combat and bombardment.[5] Spaatz also began to set requirements for pursuit types. For example, he wanted defensive pursuit (escort) to have a combat radius equal to that of bombers, but also have superior speed, strength and maneuverability. The aircraft should have a two–man crew and flexible machine–guns. He saw speed as being critically important and was willing to sacrifice climb performance and maneuverability for greater speed.[6] Spaatz's ideas were not universally shared. For example, Brig. Gen. Billy Mitchell, Assistant Chief of the Air Service, did not consider bomber escort to be a primary role for pursuit aircraft.[7] Also, there was little urgency given in the 1920s to development of escort fighters because the performance limited bi–plane bombers could not strike distant targets. "From the end of the first World War until the beginning of the thirties, American aviation policy was essentially oriented to the idea of continental defense. In addition, the general performance of military aircraft at that time precluded an attack on the United States from another continent. The need for [pursuit] aircraft with a long reach was, therefore, not urgent."[8]

The Struggle to Fund Air Power

Aviation advocates wrestled with emerging air power doctrine in a climate of constrained military budgets resulting from the massive post–World War I demobilization. Following the war the American public returned to isolationism, desiring a small military only for continental defense. The combination of tight military budgets and lack of air power doctrine led to tensions between the military services and within the Army concerning how best to build American air power.

After World War I, military budgets fell through the mid–1920's resulting in across the board cuts in personnel, procurement and modernization. (Table 3 shows general trends in military expenditures.) "Equipment was almost entirely war surplus which was not only wearing out but becoming obsolescent."[9] The aviation industry, which was highly reliant on military contracts, felt the pinch of military budget reductions. An industry official lamented that "an Air Corps' order for 30 pursuit planes, priced at about $22,500 each (without spares), was regarded as a major purchase during those years."[10] Military budgets did rise toward the end of the decade, but money available for Army aviation fell below the desires of the Air Corps.

The budgetary desires of the Army aviation advocates were first documented in 1923 with the report of the Lassiter board, named after Maj. Gen. William Lassiter. This board of Army General Staff officers legitimized the Chief of the Air Service's recommendation for a ten year expansion of the Army air arm. The recommendation was to build up to a force of 2,500 aircraft consisting of attack, pursuit and bombardment aircraft that would operate independent of control by ground forces.[11] The following summarizes the effects of budgetary realities on the Lassiter board recommendations.

> Army leaders continued to argue for appropriations, but recognized reality and established financial policies to meet as best they could the 'needs of the whole army.' They avoided expensive programs which might absorb the entire budget. To give any one of the Army's programs priority in the budget would mean disaster for the rest. This was particularly true of War Department Major Project #4, the Lassiter plan for expansion of the Air Service. The Air Service was the most expensive branch of the Army, and the Lassiter program would make it considerably more expensive. Discounting overhead such as pay and housing for Air Service personnel, the Lassiter program would have cost an estimated $90,000,000 a year, more than a third of the Army budget.[12]

Even though the recommendations of the Lassiter board were not realized during the 1920s, the Army's acceptance of the board results was an important step toward increased autonomy for the air arm. Eventually, the Army Air Corps Act of 2 July 1926 incorporated many of the Lassiter recommendations, but called for a five year expansion plan to a 1,800 airplane strong Army Air Corps.[13]

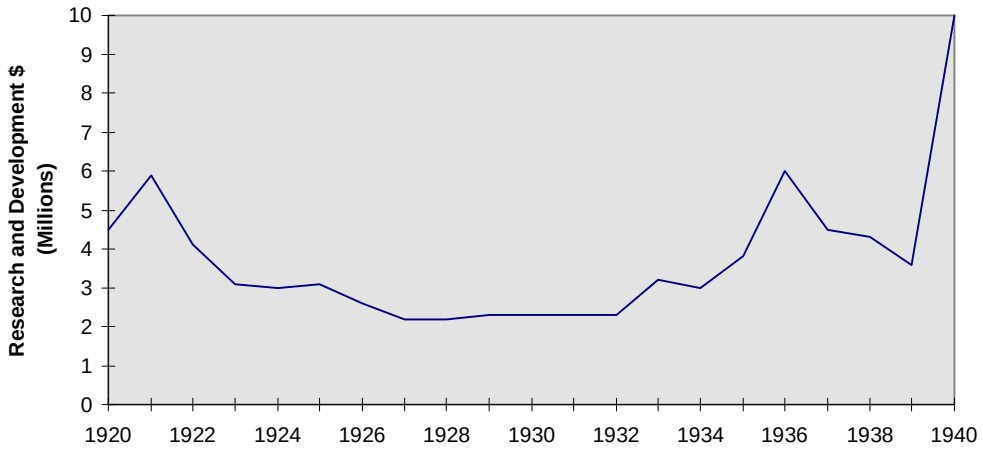
Army Versus Navy

In 1925 the Navy was building both carrier–based and shore–based aviation with their own five–year plan. Army air doctrine was placed on the back burner as the Army fought for dominance in the air. The competition focused on which service had responsibility for coastal defense of the hemisphere. While both services competed for funds to produce desired quantities of aircraft, Congress became increasingly concerned with duplication of efforts. Several joint aviation boards were formed to attempt to appease Congress by defining separate service responsibilities for coastal defense. The service chiefs finally reached an agreement (the MacArthur–Pratt agreement) where the Army was given primary responsibility for coastal air defense.[14] Even with this tenuous agreement on service roles, each service continued to fulfill their five year plans.

Army aviation expansion resulting from the Air Corps Act began in fiscal year 1928. Further attempts to cost share aviation programs with the Navy failed; therefore, the Army had to pay for the legislated Air Corps expansion with funds meant for personnel and other branches of the Army.[15] Service competition would continue into the Great Depression era of the 1930's.

Research and Development

In light of the aviation budgets, decisions were required concerning the tradeoff between producing sufficient quantities of aircraft versus developing new experimental models that made existing models increasingly obsolete. It was simply a tradeoff of quality versus quantity. While the Army General Staff pushed for standardization of existing aircraft models for mass production, General Patrick, Chief of the Air Service, emphasized research and development for fear of existing inventories becoming obsolete when compared with foreign military aircraft. The result was that funds for research and development were available and remained essentially constant from the middle 1920's through the middle 1930's.[16] Therefore, aviation technology advanced in the 1920's while combat ready inventories remained small.



Source: Plot is from data in Table 3

Figure 1 Research and Development Funding

McCook Field, near Dayton, Ohio, was the Army Air Service's center for research and development until 1927, when it moved across town to Wright Field. A sampling of experimental work performed at McCook Field includes: development and testing of new

pursuit, attack and bomber designs; development of night bombers; testing of engines and cooling systems; development of superchargers and leakproof fuel tanks; and design and testing of instrumentation and oxygen systems.[17] Aviation visionaries, such as Brig. Gen. Billy Mitchell and Rear Admirals William A. Moffett and John Towers, encouraged experimental engine work that provided the most important advances in 1920's aviation.[18] Toward the end of the decade, McCook engineers began to tackle the problem of aircraft range extension by developing dropable, external fuel tanks for pursuit aircraft.[19]

While McCook Field contributed to advancing military aviation, the Army Air Service (later called Army Air Corps) came under criticism for stifling research and development in American industry. Most aircraft companies had research departments, but found that there was no military market for innovative ideas.[20] While metal mono–plane designs had been on industry design boards throughout the 1920s, the military seemed only interested in purchasing incremental improvements on World War I type bi–plane designs. It was not until May 1929, when the Air Corps contracted Boeing for an experimental monoplane fighter, that the door was opened to innovation and the constraints of bi–plane designs were lifted.[21] The new decade would bring increased aircraft speeds and range, especially for multi–engine bomber aircraft. Pursuit speed and performance would also increase, but effective long–range escort would not appear until the 1940s.

Notes

[1]Greer, Thomas H. *The Development of Air Doctrine in the Army Air Arm 1917 – 1941*. Reprint of September 1955 edition. Washington, D. C.: Office of Air Force History, United States Air Force, 1985, 39.

[2]Ibid., 45–46.

[3]Hotz, Robert, ed. *Way of a Fighter, The Memoirs of Claire Lee Chennault, Major General, U. S. Army (Ret.).* New York: G. P. Putnam's Sons, 1949, 11.

Notes

[4]Tate, James Phillip. *The Army and its Air Corps: A Study of the Evolution of Army Policy Towards Aviation, 1919 – 1941*. Indiana University, 1976, 48.

[5]Greer, 37.

[6]Boylan, Bernard. *Development of the Long–Range Escort Fighter*. USAF Historical Study No. 136. USAF Historical Division, Research Studies Institute, Air University, September 1955, 9.

[7]Ibid., 8.

[8]Ibid., 52–53.

[9]Tate, 43.

[10]Shamburger, Page and Joe Christy. *The Curtiss Hawks*. Kalamazoo, Michigan: Wolverine Press, 1972, 11.

[11]Shiner, John F. *Foulois and the U.S. Army Air Corps, 1931 – 1935*. Washington, D.C.: Office of Air Force History, United States Air Force, U.S. Government Printing Office, 1983, 23.

[12]Tate, 45.

[13]Shiner, 31.

[14]Tate, 91.

[15]Ibid., 90.

[16]Ibid., 50.

[17]Claussen, Martin P. *Materiel Research and Development in the Army Air Arm 1914–1945*. Army Air Forces Historical Studies No. 50. AAF Historical Office, Headquarters, Army Air Forces, November 1946, 21.

[18]Shamburger, 10.

[19]Boylan, 10.

[20]Bowers, Peter M. *Boeing Aircraft Since 1916*. London: Putnam and Company Ltd, 1966, 99.

[21]Ibid., 144 & 171.

Chapter 3

Bombardment Dominance in the 1930's

The technical breakthrough of the all metal mono–plane reduced many of the structural and performance limitations of bi–planes. Now, aircraft could achieve greater speeds due to lower drag and larger, more powerful engines. Also, larger aircraft could be built that could carry heavier payloads over greater ranges. These advantages of the metal mono–plane were realized in the Martin B–10 bomber, first built in 1932. This two–engine bomber could fly at 207 miles per hour, faster than the best pursuit aircraft at the time.[1] (Table 2 contains performance data for the B–10 and other bomber aircraft.) Although the B–10 still lacked the range and payload required for decisive strategic bombardment, Air Corps bomber advocates were encouraged, and they awaited further bomber improvements. The answer for bomber advocates came in 1935 with the four–engine, Boeing B–17 Flying Fortress. Its payload, range and speed provided the Air Corps with the hardware to implement the emerging doctrine of strategic bombardment. General Arnold wrote about the B–17 in his memoirs saying, "This was the first real American air power." He also described the B–17 as being "for the first time in history air power that you could put your hand on."[2]

The metal monoplane design also improved the performance of pursuit aviation. The Boeing P–26 Peashooter of 1933 was the first of many monoplane pursuit designs of the

decade. (Table 1 provides performance data on several pursuit aircraft designs.) Although pursuit aircraft performance greatly improved, the doctrine for pursuit did not advance past that of the 1920's. Speed remained a dominate characteristic for pursuit designs, and range was a parameter that could be traded–off for speed. The emergence of long range bombardment drew attention away from pursuit aviation. The 1930's was truly the decade of the long range bomber.

Bomber Dominance

Historians have credited the men of the Air Corps Tactical School (ACTS) for establishing the doctrine of daylight strategic bombardment that led to the ultimate success of America in World War II. However, ACTS can also be criticized for failing to include long–range escort in that doctrine. In 1930, the school held the opinion that escort was necessary for a successful bombardment campaign, but by the middle of the decade, many in the school claimed that escort was entirely unnecessary. This was due to the fact that bomber performance outmatched that of existing pursuits.[3]

Officially, the school continued to recommend the development of escort. Major Clayton Bissell, a pursuit instructor at ACTS, wrote in 1936 that speed differential is everything for offensive pursuit. Unless pursuit speed was 40% to 50% greater than that of bombers, pursuit was useless. He claimed that while the means of stopping bombers did not exist in 1936, the requirement still existed and that efforts to develop pursuit were needed.[4] Unofficially, few in the Air Corps believed that it was technically possible to develop interceptor pursuit with the required speed, or an escort fighter that had both the range and speed to match the bombers.[5]

"The 1930's saw bombardment rocket into a position of almost exclusive importance, while pursuit aviation fell into a limited and narrowly defensive role. This was partly the result of the technological advances in bombardment and partly of the growing influence of the Mitchell–Douhet doctrine."[6] Heavily armed, formations of high speed bombers were considered virtually invincible. General Kuter, the chief of the bomber section at ACTS, stated in his memories that the bomber advocates at ACTS (himself, Harold George, Haywood Hansell and others) closed their minds because of the speed of the B–17 and established a dogma rather than a doctrine for strategic bombing.[7]

The pursuit enthusiasts at ACTS included Claire Chennault, Earl Partridge and Hoyt Vandenberg,[8] with Chennault being the most vocal. He saw pursuit as being a multi–purpose offensive weapon. "Another stupid controversy raged over whether fighters needed range. I wanted more range built into fighters, not only for long–range escort work, but to make them capable of long–range dive–bombing and strafing attacks on an enemy's rear."[9] Chennault summed up his feelings about the relationship between bombardment and pursuit:

> Bombardment is, of course, the sledge hammer of air power. With bombardment, popularity shifted from the fighter boys, who dominated World War I in the air, to the lumbering bombers, even then growing bigger and faster. Many of the fighter aces of the Western Front switched to bombardment during the postwar years. Tremendous technical and tactical strides were made in this field while the fighters were almost completely neglected. It was this policy that forced General H. H. Arnold to admit before West Point cadets in October 1941, on the eve of Pearl Harbor, that 'frankly, fighters have been allowed to drift in the doldrums.'[10]

The Effects of Depression Era Budgets

During America's Great Depression, military budgets continued to be a source of conflict within the Army and between the services. The budget for the Air Corps did rise through the 1930's, but so did the cost of aircraft. (Table 3 shows Air Corps expenditures and Tables 1 and 2 show costs of selected aircraft.) The Air Corps was the most costly branch of the Army. Despite fears of the Army becoming too unbalanced in favor of the Air Corps, the Army fought for the Air Corps budget. The Army's overriding concern was that the Navy would take over the coastal defense role should the Air Corps loose money.[11]

The tight budgets also created friction within the Air Corps. "During the depression years Air Corps funds were slashed [with respect to appropriations versus budget requests] so drastically that there was hardly enough money to buy gas for [crews to fly] the four hours a month in the air required to collect flying pay. The battle between the bomber radicals and the handful of fighter advocates grew more bitter as the competition for money got stiffer. Bomber boys were already thinking about the then fantastic costs of the first four–engine Boeing B–17's. Every nickel spent on fighters seemed sheer waste to them. The office of the chief of Air Corps adopted the slogan, 'Fighters are obsolete,' and funds for their development and procurement were greatly reduced."[12]

As discussed earlier, many in the Air Corps doubted that technology could bring pursuit performance up to that of the bombers. Compounding this issue was the slow growth of research and development budgets. (Table 3 lists research and development budgets.) While the Air Corps budget rose approximately 350% between 1926 and 1939, research and development budgets only rose approximately 35% for the same time

period.[13] While important technical advances occurred in the 1930's, the budget situation required prioritization of efforts. The decision making process for determining research and development priorities was not straightforward.

> [Examination of research and development organization charts] does not show such esoteric factors as General Arnold's personal interest in stimulating research, his membership on the NACA [National Advisory Committee for Aeronautics], White House influence on national preparedness, congressional pressures on behalf of ideas or inventions of constituents, military attaché and other observer missions abroad, special boards like the Kilner Board, and a host of other impulses, not all of them capable of segregation and individual analysis but all with varying influence on Air Corps research and development. Nor were these government agencies operating *in vacuo*, separate from the experimental departments of industry and the laboratories of universities. All of these elements are pertinent to any serious study of research policy.[14]

The 1935 War Department Appropriation Bill Hearings gives an example of political influences on research and development. Mr. Ross A. Collins (Chairman, Subcommittee of House Committee on Appropriations) asked General Foulois (Chief of the Air Corps) about the status of testing some of his civilian constituents' research and development ideas at Wright Field. General Foulois stated that there was a large workload with military projects and congress did not authorize funds for civilian work.[15] It is unknown what the outcome of this situation was, but this was clearly a case of Congressional pressure on research and development decisions.

Development of a long–range escort fighter was not a research and development priority during the 1930's. Neither bombardment nor pursuit doctrine required it. Also, none of the influences on research and development, discussed above, pressed for such a development. The first, half–hearted recommendations for escort research came from the Air Corps Board study number two, *Multi–Engine Fighter Aircraft, 15 July 1935*. It

recommended that an experimental fighter be developed from an "existing type" for escort, "but only if it did not interfere with the progress of other branches of aviation until the need for an escort plane was demonstrated thoroughly."[16] Additionally, in 1936, the Air Corps set requirements for a continental defense interceptor, which eventually led to the extended range, Lockheed XP–38.[17] While not looking specifically for a long–range escort fighter, many programs in the 1930's looked to improve interceptor performance. Some of the most controversial of these programs were the multi–seat fighters.

Multi–Seat Versus Single Seat Pursuit

The prioritization of pursuit aviation programs sometimes failed to spend the tight budgets wisely. The most obvious example of failures to properly prioritize efforts are the multi–seat interceptor programs. The General Staff, at the urging of the War Department, sought ways to reduce the number of Aircraft types. The idea was to improve standardization, quantity of production and economy through development of multi–purpose aircraft. "It is rather difficult to understand how aviation experts could have taken this position seriously, since all experiments with multi–place pursuit, going back to World War I, had been unsuccessful."[18] Decisions were not grounded in doctrine or military utility, but were more a result of a wish that technology could produce a cheap, multi–purpose airplane.

The Air Corps gained experience with two–place pursuits in the early 1930's with the P–16 bi–plane and the P–30 mono–plane. The P–16 had a gunner sitting backwards behind the pilot to shoot aircraft coming in from the rear. The 1st Pursuit Group was unhappy with their 25 P–16s, labeling the rear gunner as useless. The Consolidated P–30

also had a rear gunner, but flight test proved the gunner to be not only useless, but had a tendency to black out during sharp turns.[19] As a result, and Air Corps board recommended in 1935 the rejection of all two place pursuit aircraft. Even so, the Air Corps bought fifty of these airplanes in 1936.[20]

Hap Arnold (Lieutenant Colonel at the time) became interested in multi–seat fighters after a series of 1934 tests. These tests pitted P–26 pursuits and simulated multi–seat fighters (B–10 bombers) against B–12 bombers. Arnold concluded that the lack of speed of pursuits could be made up for by increased fire power.[21] He recommended development of the multi–seat fighter with a three or four–man crew.[22] Such a fighter would be armed with multiple, flexible machine–guns and would also carry small bombs for dispersing enemy bomber formations.[23] Arnold also stated in the test report that escort of friendly bomber formations was a waist of pursuit resources.[24]

Chennault disagreed with many of Arnold's conclusions as well as with how the test was set up. Chennault claimed the test was flawed because the P–26 pursuits, when compared with foreign designs, were not representative of the best of single seat pursuit.[25] As opposed to Arnold's faith in the fire power from a multi–seat fighter, Chennault pressed for the more accurate, forward–firing firepower of single–seat pursuit.[26] Chennault doubted the feasibility of building a militarily useful multi–seat fighter. "Since the interceptor must have a margin of speed over the bomber, we are confronted with the technical impossibility of building an airplane very similar in characteristics to a *bomber but considerably faster than a bomber*. [Emphasis in original]"[27]

Meanwhile, engineers at Wright Field attempted to make the multi–seat fighter a reality. Their studies of a B–10 type multi–place fighter (No. 301) led to the conclusion

that the 301 would have less speed than the B–10 bomber due to the need to carry additional weight of guns and crew.[28] Chennault, as chairman of the Air Corps pursuit board "battled with Wright Field engineers against the trend toward multi–seat fighters that provided interesting engineering problems but were useless for combat."[29] At his last Wright Field meeting the board "received a telegram from the Secretary of War, urging 'most serious consideration' of a multi–seat fighter that would serve equally well as a fighter, bomber, and reconnaissance plane, because it would be cheaper if one plane could perform all the functions of military aviation."[30] The result was the 1935 Bell XFM–1 Airacuda program.

The XFM–1 was an exciting design. It was a rather large mono–plane powered by two pusher prop engines with a crew station in each engine nacelle. It had a crew of five and was armed with six guns: two forward–firing in the nose; one forward–firing in each engine nacelle; and two flexible waste guns. The problem was that the XFM–1 lacked the required performance to be useful. (The XFM–1 performance numbers are listed in Table 1.) "Comparison of XFM–1 performance with the contemporary XP–37 shows the multi–seater far behind in speed, climb, and ceiling, while the single–seater was far less expensive to build and operate. Not only was the Airacuda's speed insufficiently greater than the bombers it had to catch, but the big fighter's lack of maneuverability would have made it easy prey for single–seat escorts attacking from the rear. Nor did the unwieldy arrangement recommend itself for protecting bombers against light interceptors."[31]

The XFM–1 Airacuda was supposed to be a superior interceptor as well as an all–purpose fighter, bomber, observation, and attack plane. "The XFM–1 was to prove [to be] one of the most disappointing technical and tactical failures of the pre–World War II

period. It apparently was a case of 'too much engineering and too little tactics.'"[32] Amazingly, despite the obvious shortcomings, Air Corps ordered twelve of the aircraft, wrongly viewing it as a capability that could both destroy enemy bombers and escort friendly bombers.[33] It could do neither and never saw combat. Support of the multi–seat fighter idea from the Chief of Air Corps, ACTS, and Air Corps Board continued through 1940.[34]

Notes

[1]Tate, James Phillip. *The Army and its Air Corps: A Study of the Evolution of Army Policy Towards Aviation, 1919 – 1941*. Indiana University, 1976, 206–209.

[2]Greer, Thomas H. *The Development of Air Doctrine in the Army Air Arm 1917 – 1941*. Reprint of September 1955 edition. Washington, D. C.: Office of Air Force History, United States Air Force, 1985, 47.

[3]Ibid., 58.

[4]Bissell, Major Clayton to Capt James Parker, Letter. 8 September 1936, 248.282–20, AFHRA.

[5]Greer, 60.

[6]Ibid., 55.

[7]Oral History Interview of Gen Laurence S. Kuter by Albert F. Simpson, 1975. Typed transcript. K239.0512–810, in USAF Collection, AFHRA, 114.

[8]Ibid., 114.

[9]Hotz, Robert, ed. *Way of a Fighter, The Memoirs of Claire Lee Chennault, Major General, U. S. Army (Ret.)*. New York: G. P. Putnam's Sons, 1949, 24.

[10]Hotz, 20.

[11]Tate, 124–129.

[12]Hotz, 26.

[13]Claussen, Martin P. *Materiel Research and Development in the Army Air Arm 1914 – 1945*. Army Air Forces Historical Studies No. 50. AAF Historical Office, Headquarters, Army Air Forces, November 1946, 51.

[14]Ibid., 58.

[15]US House. War Department Appropriation Bill for 1935 Military Activities, Hearings Before the Subcommittee of House Committee on Appropriations. 73rd Cong., 2d sess., 1934, 530–531.

[16]Boylan, Bernard. *Development of the Long–Range Escort Fighter*. USAF Historical Study No. 136. USAF Historical Division, Research Studies Institute, Air University, September 1955, 19.

[17]Ibid., 46.

[18]Greer, 66.

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[19]Maurer, Maurer. *Aviation in the U.S. Army, 1919–1939*. Washington D.C.: United State Air Force Historical Research Center, Office of Air Force History, 1987, 363.

[20]Boylan, 19–20.

[21]Arnold, Lt Col H. H. To Chief of Air Corps. Letter. Subject: Employment of Tactical Units Equipped with Modern Pursuit and Bombardment Airplanes, 26 November 1934. 248.282–27 AFHRA, 3.

[22]Ibid., 11.

[23]Ibid., 12.

[24]Ibid., 13.

[25]Chennault, Capt. Claire L. To The Commandant, The Air Corps Tactical School. Letter. Subject: Comments on Letter to Chief of the Air Corps, dated November 26, 1934, 7 March 1935. 248.282–27 AFHRA, 1.

[26]Ibid., 6.

[27]Ibid., 7.

[28]Boylan, 19–20.

[29]Hotz, 29.

[30]Ibid., 29.

[31]Wagner, Ray. *American Combat Planes*. Garden City, New York: Doubleday and Company, Inc., 1968, 204.

[32]Greer, 66.

[33]Maurer, 365

[34]Greer, 121.

Chapter 4

The Escort Crisis Entering WWII

> *It is in time of peace that we must develop our technical equipment and train our personnel. We cannot do these things after the beginning of hostilities nor can we suddenly shift from one type of vital technical equipment to another after the fighting starts. Our leaders in peacetime should have sufficient imagination, vision, and experience to direct technical development and personnel training upon sound lines.*[1]
>
> Major General Claire L. Chennault

Need for Long–Range Escort Realized

The outcome of the 1938 Munich Crisis over Czechoslovakia may have allowed France and Britain to avert immediate war with Hitler's Germany, but it also served as a wake up call to the United State's government. President Roosevelt, correctly, did not trust Hitler's pledges of nonagression. The Air Corps then had 2,100 serviceable combat aircraft. The President called for production of 10,000 more aircraft over the next two years.[2] With the threat of war, military aviation budgets for production and research and development climbed. For example, the Air Corps research and development budget jumped approximately 180% from 1939 to 1940, allowing Wright Field to increase its workload from one major aircraft project in 1939 to six in 1940.[3]

By 1939, General Arnold and other bomber advocates were beginning to question the invincibility of self–protecting bomber formations. They had received foreign reports

where bombers were experiencing losses to pursuit.[4] In particular, the Spanish Civil War proved to Arnold that pursuit aircraft could indeed cause heavy losses to unescorted bombers. A Russian report, for example, stated that: "Enjoying greater speed and maneuverability than bombing craft, as well as greater ceiling, the pursuit craft always found themselves in a favorable position in aerial combat and were quite successful in their action against bombers."[5]

General Arnold directed boards to form with the purpose of prioritizing Air Corps development efforts. The Emmons Board, named for Major General Delos C. Emmons, commanding general of the GHQ Air Force, set the Air Corps priorities as: (1) development of a very long range heavy bomber; (2) development of a twin engine interceptor; (3) development of a medium long range bomber; and (4) development of an escort fighter with 1500 mile range. Arnold swapped places of the #1 and #4 priorities, making development of a long–range escort fighter his first priority. "The importance of the fighter had obviously come home to Arnold, but his assignment of research and development priority to the long–range escort came late and did not result in a quick technological fix."[6] One historian captures Arnold's growing desperation for long–range escort:

> With the outbreak of World War II, distances to Europe and a shortage of shipping renewed interest in external tanks. After a meeting on 20 February 1942, Army Air Forces' chief Arnold ordered the all–out development of auxiliary tanks for the P–51, P–38, and P–47 in response to demands from his field commanders and his own growing doubts over the invincibility of the bomber. Progress was slow. Under pressure of events in Europe, in June 1943 Arnold gave Barny Giles [Chief of the Air Staff] 6 months 'to get a fighter that can protect our bombers. Whether you use an existing type or have to start from scratch is your problem. Get to work on this right away because by January '44, I want fighter escort for all of our bombers from U.K. into Germany.' Assistant Secretary of War

> for Air Robert A. Lovett added urgency to Arnold's demands in June after an investigative trip to England revealed the need for long–range escort.[7]

Even while General Arnold was pressing for long–range escort development, others in the Air Corps were not convinced of the urgency. For example, Air Corps Study number 35 in May 1939 concluded that development of an escort with both the range and performance needed for combat was unlikely. "It considered desirable, but impractical, the employment of fighter aircraft in defense of bombardment units operating far within enemy territory." Instead it recommended concentration on offensive, short range fighters that would attack bombardment over friendly territory.[8] Various pursuit groups also expressed opinions concerning the utility of escort. While bombardment advocates began a push to develop escort fighters, the pursuit community began questioning the need for bomber formations given the high altitudes and speeds of individual bombers. There were even concerns voiced that the presence of escorts would give away the location of bombing formations.[9] "Besides the ambiguity of the opinions expressed by officers on the need for long–range escorts, there was still no clearly defined statement on the kind of pursuit planes needed by the Air Corps."[10]

Solutions to Escort Problem

Another Air Corps board continued to look at the long–range escort problem in December 1939. Board recommendations for study included having the bombers aerial refuel the escorts and having the bombers carry small escort aircraft that could be released when the enemy interceptors appear.[11] Engineers studied these problems, but these ideas did not appear in the war. One other idea that continued to emerge was the multi–seat fighter.

Multi–Seat Fighters Fail Again

Many Air Corps leaders, including General Arnold, continued to hope for the development of an effective multi–seat fighter. For example, the 8th pursuit group recommended in 1938 the development of a multi–seat aircraft with a slightly greater range than bombardment and armed with twelve to fifteen 0.50–caliber machine–guns.[12] Apparently they were advocating, as Arnold had done earlier in the decade, that superior firepower was the key to air superiority.

In October 1941 the pursuit board (without Chennault) recommended the development of a convoy defender, that would be a long–range, multi–seat escort.[13] "Convoy fighters [would have] much the same speed and range as the bombers they are designed to defend, plus strong armor and heavy fire power. This is a highly controversial subject, and so far it is not known whether any such aircraft can or will be built. 37mm flexible cannon or even larger may be used in such fighters."[14] Perhaps the board took some lessons from the XFM–1 experience in that the convoy fighter would have the single purpose of defending bomber formations. The board went so far as to recommend specialization of seven different types of pursuit aircraft.[15]

May 1943 saw the development and combat use of the YB–40 aircraft. The YB–40s were B–17s converted into gunships by adding armor plating, fourteen 0.50–caliber guns with 11,200 rounds, and chin turrets. Not surprisingly, this aircraft had no combat utility because it could not keep up with the bomber formations it was supposed to protect.[16] Even worse, since the YB–40 did not carry bombs, the bomber formation lost payload carrying capability for an insignificant increase in defensive firepower.[17] Clearly, multi–seat fighters were not the answer to the long–range escort problem.

Drop Tanks

Adding external fuel tanks to existing pursuit aircraft seemed like a logical solution to extending pursuit range. Making the tanks dropable in flight preserved maneuverability and performance when required for combat. Experiments with dropable fuel tanks had been conducted throughout the 1920's and 1930's. The greatest concern about drop tanks was the hazard of fire. In February 1939, Curtiss–Wright wanted to test a 52–gallon tank mounted on the bomb rack of a P–36C, but the "Chief of the Air Corps directed that no tactical plane be equipped with a dropable fuel tank" because of the potential for fires.[18] Another downside of drop tanks was that the effectiveness of escort with drop tanks depended on when the enemy attacked. If the enemy attacked early, the escort would have to jettison their tanks and would not be able to continue the escort mission.[19] By 1940 the urgency of range extension programs became critical. General Arnold saw drop tanks as a solution and made external fuel tank development a high priority in the Spring of 1941.[20] P–47s and P–38s were retrofitted with drop tanks and became the interim solution to the escort problem. Still, as discussed in the introduction, American bomber formations experience heavy losses over Germany. The tide turned with the emergence of the P–51 Mustang.

P–51 Mustang

The North American P–51 Mustang was not designed for American long–range escort. It was developed as an export aircraft for the British as a result of the Munich Crisis in 1938.[21] Engineers specifically designed the aircraft for reduced drag. It had laminar flow wings, smooth shaping and a special radiator placement. The original designs were powered by Allison V–1710–F36 engines, which were not supercharged and

therefore lacked performance at higher altitudes.[22] The aircraft was therefore given the roles of ground attack and armed reconnaissance when it entered operational service with the British in 1942.[23]

Fortunately, a stipulation in North Americans' contract with Britain required the company to provide the US Army with two copies for testing. At first the Army was not overly interested in the aircraft, however operational units had borrowed Mustangs for combat missions in North Africa and liked them. The Army Air Forces let a P–51 production contract to North American in 1943.[24] The P–51's potential use as a long–range escort came when the airframe was married with a supercharged, Rolls–Royce Merlin engine. This configuration provided a long–range fighter with performance superior to that of German fighters. By January 1944, P–51B's were proving themselves to be superior long–range escort fighters.

Notes

[1]Hotz, Robert, ed. *Way of a Fighter, The Memoirs of Claire Lee Chennault, Major General, U. S. Army (Ret.)*. New York: G. P. Putnam's Sons, 1949, 24.

Maurer, Maurer. *Aviation in the U.S. Army, 1919–1939*. Washington D.C.: United State Air Force Historical Research Center, Office of Air Force History, 1987, 435–436

[3]Claussen, Martin P. *Materiel Research and Development in the Army Air Arm 1914 – 1945*. Army Air Forces Historical Studies No. 50. AAF Historical Office, Headquarters, Army Air Forces, November 1946, 28.

[4]Greer, Thomas H. *The Development of Air Doctrine in the Army Air Arm 1917 – 1941*. Reprint of September 1955 edition. Washington, D. C.: Office of Air Force History, United States Air Force, 1985, 120.

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[7]Ibid., 103.

[8]Boylan, Bernard. *Development of the Long–Range Escort Fighter*. USAF Historical Study No. 136. USAF Historical Division, Research Studies Institute, Air University, September 1955, 24.

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[9]Ibid., 24.
[10]Ibid., 28.
[11]Ibid., 31–33.
[12]Ibid., 23.
[13]Ibid., 36–41.
[14]Spaatz, Brig. Gen. Carl. Untitled report from board of officers, dated 2 October 1941. 168.15–5 AFHRA, 11.
[15]Ibid., 6.
[16]Wagner, Ray. *American Combat Planes*. Garden City, New York: Doubleday and Company, Inc., 1968, 126.
[17]McFarland, 101–102.
[18]Boylan, 45–46.
[19]Ibid., 17.
[20]Claussen, 103.
[21]Jackson, Robert. *Mustang the Operational Record*. Washington, D. C.: Smithsonian Institution Press, 1992, 1–2.
[22]Ibid., 3–4.
[23]Ibid., 7–8.
[24]Ibid., 22&24.

Chapter 5

Conclusions

Even a cursory study of American involvement in World War II would clearly indicate that the doctrine of daylight strategic bombardment contributed significantly to the Allied victory. It is just as clear that America paid a terrible price in terms of human life and treasure in carrying out the strategic bombardment of Germany. Historians have blamed America's lack of long–range escort for many of the bomber losses. There is no one individual or organization that is responsible for the neglect of long–range escort development. However, this paper has discussed several factors, tensions and errors in judgment that contributed to the lack of urgency in developing a suitable long–range escort. The basic cause for peacetime negligence of long–range escort development was that air power decisions were influenced more by budget considerations and less by sound doctrine.

Air Power Doctrine

Aircraft technology had advanced in the interwar years to a point where World War I aircraft and most World War I tactics had become obsolete. America entered World War II with a powerful air arm that was completely untested in battle. America's air power doctrine was driven by technical advances and consisted of untried theories. Technology

did not allow for long range pursuit without having to tradeoff other highly desired performance characteristics. Also, air power theory did not place urgency on the development of long–range escort.

Military aviation in the 1920's was dominated by World War I ideas of air power, where the aircraft's primary role was to support the ground commander. Pursuit aviation was generally viewed as being necessary to destroy enemy aircraft and thereby gain air superiority. A few theorists advocated the idea of air power being decisive in war through strategic bombardment of the enemy homeland; however, bi–planes could not provide the performance to make decisive strategic bombardment a reality. Additionally, isolationist America in the 1920's was more interested in coastal defense than in offensive strikes against another country. The roles of aviation in the 1920's did not require long–range escort. In fact, range was a less important factor for pursuit aviation than speed, maneuverability and armament.

The 1930's saw the advent of the all metal mono–plane that yielded aircraft capable of making decisive strategic bombardment a reality. Early in the decade strategic bombardment theorists included fighter escort in the strategic bombardment theory, but when the speeds of the multi–engine bombers outstripped the speeds of pursuit, fighter escort was excluded from the theory. The Air Corps became polarized between bomber and pursuit advocates, and a doctrine emerged stressing the invincibility of self–protecting bomber formations while devaluing pursuit. Increased speed became the ultimate goal for pursuit aircraft design, even at the expense of range.

Reports from the Spanish Civil War showed that America's strategic bombardment doctrine was flawed by not including escort fighters for air superiority. This caused Air

Corps leaders to become concerned about America's lack of long–range escort fighters. This late realization prompted the urgent programs that eventually produced an effective long–range escort, but not until after many bombers and crews had been lost.

The Influence of Budget

The airplane proved its worth as a weapon in World War I, but it was also an expensive weapon. During the interwar years, the airplane had become more than just a weapon. Air power had become a source of political power and prestige. To most military and political leaders the important ingredient for attaining air power was money that would buy large quantities of destructive, high–performance aircraft. Pursuit aviation, including long–range escort fighters, was viewed as being defensive and therefore less important to air power than the offensive bombers. The desire to attain air power in an era of constrained budgets drove most decisions concerning aircraft development and procurement.

Both the Army and Navy attempted to build their respective air arms in the 1920's, but the peacetime budgets restricted their efforts. This led to clashes over roles, in particular the role of coastal defense. It became obvious to each service that building an air arm was an expensive undertaking. The Army could not build up the Air Corps to the desired quantity of aircraft without sacrificing ground forces. Further complicating the budget issues was the tradeoff of funding research and development or quantity production. Concerned by advances in foreign aircraft performance, the Air Corps emphasized research and development leading to continuous improvements in aircraft performance throughout the decade.

The Great Depression and the increasing cost of aircraft continued tensions in funding the services' air arms. Funding for Air Corps research and development did not keep pace with the funding for the rest of the Air Corps, requiring prioritization of programs. Bomber advocates attempted to devalue the role of pursuit aviation in order to increase the priority of bomber programs, and requirements for long–range escorts became lost. Military leaders tried to press for all–purpose aircraft that would add value to offensive air power, and at the same time be able to perform the defensive roles. The development of the XFM–1 was an example of a misguided effort to build an all–purpose aircraft that could also serve as a long–range escort.

Military budgets and aircraft production programs drastically increased as a result of the 1938 Munich crisis, and the military found it had money to buy huge quantities of aircraft. However, war proved that doctrine was an indispensable ingredient of air power. The large quantities of strategic bombers required the addition of long–range escorts before air power could be implemented without unacceptable losses.

Appendix A

Selected Military Aircraft of the Interwar Years

Tables 1 and 2 contain information about selected pursuit and bombardment aircraft that were developed during the years between World War I and World War II. Entries are listed in chronological order. The information is not meant to be definite or exhaustive. The purpose of the tables is to allow the reader to see general trends in aircraft costs and in aircraft and engine performance improvements. In general, the tables show that performance significantly improved with time. Also, aircraft costs increased dramatically with time.

Sources of aircraft data do not always provide the same performance and cost information. Some of the differences in data stem from the fact that military aircraft designs were undergoing constant upgrades and were bought in different lot sizes. The cost data are presented in then year dollars, and are generally consistent with Air Corps Materiel Division financial reports.[1] The data presented here are considered adequate for presenting general trends.

Notes

[1]For example, Robins, Brig. Gen. A. W. Twelfth Annual Report, Chief, Materiel Division, Air Corps, US Army Fiscal Year 1938. Wright Field, Dayton OH, 27 August 1938. From HQ AFMC/HO files.

Table 1 Information on Selected Pursuit Aircraft

Aircraft	Year	Manufacturer	Top Speed (MPH)	Cruise Speed (MPH)	Max Range (Miles)	Service Ceiling (feet)	Armament	Engine (s)	Prod. Unit Cost	Notes
PW–8 Hawk	1926	Curtiss	178	160	335	22,000	2 Machine guns	1–Curtiss D–12 440 hp	$10,000	bi–plane sources 1&2
PW–9	1926	Boeing	165	124	350	20,175	2 Machine guns	1–Curtiss D–12D 435 hp	$10,000	bi–plane source 2&3
P–12	1929	Boeing	189	160	570	26,300	2 Machine guns 244lb of bombs	1–Pratt&Whitney R–1340–17 500 hp	$15,000	bi–plane source 4
P–6E Hawk	1932	Curtiss	204	167	480	24,400	2 Machine guns	1–Curtiss V–1570 600 hp	$13,000	bi–plane source 5
P–26 Peashooter	1934	Boeing	234	200	620	27,400	2 Machine guns 110 lb of bombs	1–Pratt&Whitney Wasp 600 hp	$20,000	mono–plane fixed gear source 3&6
P–35	1937	Republic	280	260	625	30,600	2 Machine guns 320 lb of bombs	1–Pratt&Whitney R–1830 850 hp	$22,500	mono–plane retract. gear source 5
P–38 Lightning	1937	Lockheed	414	275	1,100	40,000	4 Machine guns 1 – 20mm can.	2–Allison V–1710 1,475 hp each	$115,000	2– engine twin boom source 5
XFM–1 Airacuda	1937	Bell	300	250	2,000	30,500	4 Machine guns 2 – 37mm can. 600 lb of bombs	2–Allision V–1710 1,150 hp each	$260,000	5 man crew sources 7, 8 & 9

Table 1 Information on Selected Pursuit Aircraft (Continued)

Aircraft	Year	Manufacturer	Top Speed (MPH)	Cruise Speed (MPH)	Max Range (Miles)	Service Ceiling (feet)	Armament	Engine (s)	Prod. Unit Cost	Notes
P–36 Hawk	1938	Curtiss	313	250	830	32,700	2 Machine guns	1– Pratt&Whitney R–1830 1,050 hp	$23,000	mono–plane source 5
P–39 Airacobra	1939	Bell	376	250	650	35,000	4 Machine guns 1–37mm can. 500 lb of bombs	1–Allision V–1710 1,200 hp	$46,000	mono–plane source 5
P–40 Warhawk	1941	Curtiss	362	235	850	30,000	6Machine guns 700 lb of bombs	1–Allision V–1710 1,150 hp	$45,000	mono–plane source 5
P–59 Airacomet	1941	Bell	450	320	440	43,400	3 Machine guns 1–37mm can.	2– General Elec. I–16 jet 1650lbs thrust ea	Not Produced	1st US jet fighter source 5
P–47 Thunder–bolt	1941	Republic	433	260	1,100 w/ drop tanks	40,000	8 Machine guns 10 – 5” rockets	1– Pratt&Whitney R–2800 2,300 hp	$94,000	mono–plane source 5
P–51 Mustang	1942	North American	437	275	1,240 w/ drop tanks	41,900	6 Machine guns 10 – 5” rockets	1–Rolls–Royce Merlin V–1650 1,695 hp	$54,000	mono–plane source 5

Source 1: Greer, Thomas H. *The Development of Air Doctrine in the Army Air Arm 1917–1941*. Reprint of September 1955 edition. Washington, D. C.: Office of Air Force History, United States Air Force, 1985. Page 38.

Source 2: Wagner, Ray. *American Combat Planes*. Garden City, NY: Doubleday and Company, Inc., 1968. Pages 172, 174, and 203.

Source 3: Angelucci, Enzo ed. The Rand McNally Encyclopedia of Military Aircraft 1914–1980. New York: The Military Press, 1983. Page 120.

Source 4 U.S. Air Force Museum home page, n.p. On–line. Internet, 15 February 1997. Available from http://www.wpafb.af.mil/museum/early_years/ey12.htm

Source 5: *United States Air Force Museum*. Wright–Patterson AFB, Ohio: Air Force Museum Foundation, Inc. Pages 20, 24, 30, 35, 54, 60, 65, and 73.

Source 6: Bowers, Peter M. *# 14, The Boeing P–26A*. England: Profile Publications Ltd., 1965.

Source 7: Robins, Brig. Gen. A. W. Twelfth Annual Report, Chief, Materiel Division, Air Corps, US Army Fiscal Year 1938. Wright Field, Dayton OH, 27 August 1938. From HQ AFMC/HO files.

Source 8: Grey, C.G., and Leonard Bridgman, eds. *Jane's All the World's Aircraft 1940.* London: Sampson Low, Marston & Company, Ltd., 1941. Page s155c–156c.

Source 9: Maurer, Maurer. *Aviation in the U.S. Army, 1919–1939*. Washington D.C.: United State Air Force Historical Research Center, Office of Air Force History, 1987. Page 364.

Table 2 Information on Selected Bombardment Aircraft

Aircraft	Year	Manufacturer	Top Speed (MPH)	Cruise Speed (MPH)	Max Range (Miles)	Service Ceiling (feet)	Armament	Engine (s)	Prod. Unit Cost	Notes
B–4A	1929	Keystone	121	103	855	14,000	3 Machine guns 2500 lbs bombs	2–Pratt&Whitney Hornet 575 hp each	$25,000	bi–plane source 1&2
B–10	1932	Martin	215	183	1,370	24,000	3 Machine guns 2200 lbs bombs	2–Wright R–1820 775 hp each	$55,000	mono–plane source 3
B–17 Flying Fortress	1935	Boeing	300	170	1,850	35,000	13 Machine gun 5000 lbs bombs	4–Wright R–1820 1,200 hp each	$150,000	mono–plane source 3
B–18	1937	Douglas	226	167	1,200	27,150	3 Machine guns 6500 lbs bombs	2–Wright R–1820–53 1,000 hp each	$85,000	mono–plane source 1&2
B–25 Mitchell	1941	North American	275	230	1,200	25,000	5 Machine guns 5000 lbs bombs	2–Wright R–2600 1,700 hp each	$96,000	mono–plane source 3
B–24 Liberator	1942	Consolidated	303	175	2,850	28,000	10 Machine gun 8000 lbs bombs	4–Pratt&Whitney R–1830 1200 hp each	$336,000	mono–plane source 3
B–29 Super–fortress	1942	Boeing	357	220	3,700	33,600	10 Machine gun 1 – 20mm can. 20,000 lb bomb	4–Wright R–3350 2,200 hp each	$639,000	Mono–plane source 3

Source 1: Angelucci, Enzo ed. The Rand McNally Encyclopedia of Military Aircraft 1914–1980. New York: The Military Press, 1983. Page 143.

Source 2: Wagner, Ray. *American Combat Planes.* Garden City, NY: Doubleday and Company, Inc., 1968. Page 111.

Source 3: *United States Air Force Museum.* Wright–Patterson AFB, Ohio: Air Force Museum Foundation, Inc. Pages 21, 34, 52, 56, and 76.

Appendix B

Selected Monetary Information for the Interwar Years

Table 3 contains a mixture of expenditure and appropriation information for military aviation for the years 1917 to 1944. All values are approximate then–year dollars, and are not intended to be definite. The purpose of the table is to allow the reader to see general trends in military aviation funding, including research and development appropriations. In general, funds for military aviation fell dramatically immediately following World War I, then grew slowly, and finally rose rapidly on the eve of World War II. Air Corps research and development appropriations remained fairly constant until the mid–1930's when the appropriations generally increased.

Consistent data of military aviation funding are difficult to find for the time period. As noted in the table, the data were compiled from various sources and consist of both appropriations and expenditures. Despite the limitations of the data, the table is considered sufficient to show general trend information.

Table 3 Military Aviation Funding Information

Year	Total Military Expenditures * ($Millions)	Army Aviation Expenditures * ($Millions)	Navy Aviation Expenditures * ($Millions)	Military Aviation Expenditures* ($Millions)	Air Corps R&D** ($Millions)
1917		19	4	23	
1918		681	62	743	
1919		952	220	1172	
1920		28	26	54	4.5
1921		35	20	55	5.9
1922	935			37	4.1
1923	730			36	3.1
1924	689			28	3.0
1925	717			25	3.1
1926	677			31	2.6
1927	688			32	2.2
1928	732			42	2.2
1929	732			52	2.3
1930	839			57	2.3
1931	833			69	2.3
1932	834			65	2.3
1933	784			53	3.2
1934	706	17	16	33	3.0
1935	924	20	22	42	3.8
1936	1148	32	23	55	6.0
1937	1185	41	27	68	4.5
1938	1240	51	61	112	4.3
1939	1368	83	48	131	3.6
1940	1799	108	50	158	10.0
1941	6252	605	191	796	
1942	22905	2555	1063	3618	
1943	63153	7933	3847	11780	

* Years 1917 through 1921 are Appropriations. Data derived from: Modley, Rudolf ed. *Aviation Facts and Figures 1945*. New York: McGraw–Hill Book Company Inc., 1945. Pages 53–55.

** Research and Development Appropriations from: Claussen, Martin P. *Comparative History of Research and Development Policies Affecting Air Materiel 1915–1944*. USAF Historical Study No. 20, June 1945. Page 49.

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