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NOT A POUND FOR AIR-TO-GROUND:

A HISTORIOGRAPHICAL ANALYSIS ON THE GENESIS OF THE MULTI-ROLE FIGHTER

by

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Abstract

The history of military aviation illustrates the value of a fighter-type aircraft that excels in many different mission sets; virtually every air-to-air fighter has been modified for air-to-ground operations. Through an analysis of a century of American fighter development and employment, the author proves conclusively the most effective multi-role fighters grew from a design that prioritized effective air-to-air combat operations over air-to-ground. Once air-to-air fighters became obsolete due to maneuverability, technology, or needs of the force changed, leadership reconfigured them to become multi-role fighters, capable of effective air-to-ground operations, while still able to protect themselves from the air threat. The characteristics of successful multi-role fighters, specifically maneuverability, acceleration, rate of climb, high top speed, cockpit visibility, large payload, high ceiling, balanced technology, and an internal cannon, mimic those of successful air superiority fighters. It is certainly vital to think about and plan for future operations; however, it is imperative not to ignore historical combat lessons learned. Future fighter procurement must prioritize an air superiority fighter design, which can then be modified to achieve effective multi-role operations.

Introduction

Weapon systems procurement seeks to balance capability and versatility. The nature of aerial warfare demands combat capable aircraft within political, budgetary, and technological constraints. In the history of the United States Air Force (USAF), and its Army predecessors, military leadership initially designed many fighter-type aircraft for an air-to-air role.[1] Once these fighters became obsolete due to maneuverability, technology, or needs of the force changed, leadership reconfigured them to become multi-role fighters, capable of effective air-to-ground operations, while still able to protect themselves from the air threat. History teaches the value of a fighter-type aircraft that excels in many different mission sets, and "virtually every fighter designed to undertake air-to-air combat...has subsequently been modified to undertake ground-attack duties as well."[2] Other historiographical works do not specifically compare the design and resulting combat value of multi-role fighters.[3] An argument focused on the evolution of fighter aircraft proves conclusively that the most effective multi-role fighters, primarily fighter-bombers, grew from a design that prioritized effective air-to-air combat operations over air-to-ground.

World War One

WWI was the first real test of military aviation; the airplane's initial role was as an unarmed, airborne reconnaissance and artillery spotter.[4] After only three months of combat, the

[1] A fighter is an air-to-air platform; a fighter-bomber is a fighter-type aircraft used for both air-to-air and air-to-ground operations. A multi-role fighter is a fighter-bomber that is adapted for additional roles besides the pure air-to-air and air-to-ground missions (i.e. Forward Airborne Controller-Airborne (FAC-(A)), Suppression/Destruction of Enemy Air Defenses (SEAD/DEAD), Electronic Warfare (EW), or Reconnaissance). Engineers designed interceptors to intercept and shoot down enemy bombers. For the purposes of the WWII discussion, attack aircraft and medium-bomber are interchangeable, since their employment was comparable.

[2] Richard P. Hallion, *Strike from the Sky* (Washington D.C.: Smithsonian Institution Press, 1989), 50.

[3] Comparing and contrasting fighter and multi-role fighter design across conflicts reveals significant debate regarding the value of single-role air-to-air, Close Air Support (CAS), and attack platforms; propeller versus jet-driven aircraft; and heavy bombers involved in CAS operations. However, this argument will focus on the combat effectiveness of fighter and multi-role fighter design.

[4] Alan Clark, *Aces High: The War in the Air over the Western Front 1914-18* (New York: G.P. Putnam's Sons, 1973), 18.

pilots requested a forward firing machine, and airplane design quickly evolved into single-role air-to-air fighters.[5] WWI was an operational testing ground for the evolution of the fighter-bomber; rapid procurement of fighter aircraft was necessary since aircraft become obsolete within a year, if not several months, of arriving at the front lines. Early fighter aircraft became obsolete due to the rapid increase of speed, maneuverability, and forward firing power technology produced by aircraft designers over the course of the war; more maneuverable and lethal air-to-air fighters quickly overcame the adversary, relinquishing their now obsolete aircraft to the subordinate roles of reconnaissance and ground attack.[6] Subsequently, WWI fighters were always inherently multi-role; their primary mission may have been air superiority, but their secondary mission was ground attack or battlefield support.[7]

Failure in the U.S. procurement process relegated American pilots to flying French aircraft.[8] "The officials responsible for developing the aerial weapon of the United States had failed to achieve the necessary balance between superior performance and mass production. In their efforts to perfect a superior fighter they produced none at all."[9] By the end of the war, the average single-seat, single-engine, high performance fighter "had an endurance of over two hours, had a maximum speed of 120 mph, relied upon a 180-200-hp engine, and could carry a mix of weaponry including twin forward-firing synchronized machine guns and light bombs."[10] The resulting aircraft design lesson of WWI revealed the importance of a multi-role fighter "with multiple machine guns and racks for bombs, capable of attaining high speed and operating with

[5] Ibid., 49.
[6] Ibid., 56; Irving Brinton Holley, *Ideas and Weapons: Exploitation of the Aerial Weapon by the United States During World War I; A Study in the Relationship of Technological Advance, Military Doctrine, and the Development of Weapons* (Washington D.C.: Office of Air Force History, 1983),152.
[7] Hallion, *Strike from the Sky*, 16.
[8] Holley, *Ideas and Weapons*, 106; Alfred F. Hurley, *Billy Mitchell: Crusader for Air Power* (Indiana: Indiana University Press, 1975), 33.
[9] Holley, *Ideas and Weapons*, 132.
[10] Hallion, *Strike from the Sky*, 14-15.

great maneuverability and agility."[11] Furthermore, "[u]nescorted or poorly escorted bomber raids were massacred...pointing to the vulnerability of the unescorted bomber, a vulnerability that would reveal itself in subsequent conflicts."[12]

Interwar Years

The "rapid development of strategic bombing" theory during the interwar years removed the focus from tactical air power lessons learned during WWI.[13] The attack aircraft came into vogue at this time, due largely to "the increasing performance disparity of the single-engine attack airplane."[14] Single-role combat aircraft theory held onto three kinds of aircraft: bomber, attack, and fighter; Air Corps Field Manual (FM) 1-5 emphasized the theory of the time by stating that fighters "were 'not suitable' for ground attack 'other than personnel or light material' except for temporary employment during emergencies."[15]

Air power theorists at the time ignored the lessons of WWI regarding a balanced approach to combined arms and tactical and strategic aviation; they believed technology rendered those lessons obsolete. Eerily reminiscent of modern-day discussion regarding the future of Air Force procurement, a senior instructor at the Air Corps Tactical School (ACTS) stated, "We are not concerned with fighting the last war...that was done eighteen years ago. We are concerned, however, in determining how air power shall be employed in the next war and what constitutes the principles governing its employment."[16] It is certainly vital to forward think and plan for future contingency operations; however, it is imperative not to ignore lessons learned from previous wars by assuming that technology will overcome lessons learned. A

[11] Ibid., 37.
[12] Ibid., 26.
[13] Ibid., 46.
[14] Ibid., 49.
[15] Ibid., 50.
[16] Thomas Alexander Hughes, *Over Lord: General Pete Quesada and the Triumph of Tactical Air Power in World War II* (New York: The Free Press, 1995), 53.

balanced approach is necessary and, as can be seen from WWII, relying on technological advances to provide a decisive outcome may not achieve the desired tactical or strategic effect. This discussion is not an attempt to suggest that the U.S. sacrificed *all* tactical air power at the expense of strategic bombing; however, U.S. planners did not fully understand effective design and employment of tactical aviation in pursuit of strategic effects.[17] They focused on single-seat, single-engine fighters for air-superiority and twin engine attack aircraft for support of ground forces; "...the school's stress on bombardment [left] little room for development of any other ideas. In lectures, class time, and graded material, no topic suffered more than instruction in air-ground operations."[18] In 1939, planners focused on attack aviation for tactical battlefield support and interdiction, instead of multi-role fighters. The development of technologies such as radar, anti-aircraft weapons, and more capable single engine aircraft led to the employment of traditional attack aircraft, such as the Douglas A-20, as a medium-altitude bomber during WWII.[19] Subsequently, traditional fighters, designed to intercept and shoot down bombers and attack aircraft, evolved into multi-role fighters assuming the "traditional role of the 'attack' airplane—striking at ground targets with bombs and machine-gun fire delivered from low-altitude terrain-hugging attacks."[20]

World War Two

North Africa and Italy

WWII revealed the fighter-bomber as a mainstay of tactical airpower, which permeates tactical aviation theory today. Even before the declaration of war against the Axis powers, the U.S. Army Air Forces (USAAF) "assigned advisers, representatives, and observers...to observe

[17] Christopher M. Rein, *The North African Air Campaign: U.S. Army Air Forces from El Alamein to Salerno* (Kansas: University Press of Kansas, 2012), 10.
[18] Ibid., 32.
[19] Hallion, *Strike from the Sky*, 48-55.
[20] Ibid., 50.

combat" with the British in North Africa in an attempt to learn from their practical experience. [21] They witnessed Coningham's effective use of fighter-bombers through the initial stages of this campaign; the British indoctrinated them into the mindset that "[e]very fighter should be a *fighter-bomber*, with jettisonable tanks and bombs interchangeable."[22] The primary USAAF fighter aircraft in North Africa were the P-38, P-39, and P-40; designers planned the P-38/39 as interceptors and the P-40 as a single-role air-to-air fighter.[23] The Luftwaffe's Messerschmitt (Me) -109 and Focke-Wulf (Fw) -190's maneuverability allowed them to quickly outclass the P-39.[24] Planners rapidly transferred the P-39 to air-to-ground only missions where it performed admirably; however, its lack of air-to-air self-protection capability forced American Spitfires, which did not have sufficient range to escort heavy bombers, to escort it over the battlefield.[25]

The P-40 was the quintessential fighter-bomber in North Africa; pilots escorted bombers to the targets, shot down enemy fighters, and strafed the airfields after the bombers dropped their payloads.[26] Subsequently, the U.S. loaded bomb racks on the P-40s so they could employ with the bombers; if an air-to-air engagement was imminent, they jettisoned their ordnance to be more maneuverable. Even though the P-40 was not as maneuverable as the German fighters, "when properly handled, [it] could provide a close match;" therefore, it became the primary Close Air Support (CAS) and Battlefield Air Interdiction (BAI) fighter-bomber in support of the ground forces, where it could defend itself from air-to-air attacks.[27]

The P-38 was extremely effective in its escort of heavy bombers early in the European Theater of Operations (ETO); the lack in complete superiority over German fighters in North

[21] Rein, *North African Air Campaign*, 32.
[22] Vincent Orange, *Coningham: A Biography of Air Marshal Sir Arthur Coningham* (London: Methuen, 1990), 145.
[23] Hallion, *Strike from the Sky*, 51.
[24] Rein, *North African Air Campaign*, 117, 215.
[25] Ibid., 117.
[26] Ibid., 44-45, 61.
[27] Ibid., 216.

Africa led to General Tooey Spaatz's request for P-38s from Europe.[28] Its unique design allowed it to "perform long-range escort missions" and made it maneuverable in air-to-air combat."[29] P-38s escorted heavy bombers on operational level missions, freeing up other fighter-bombers to support tactical level missions such as CAS and BAI, inherently important in the strategic success of the war.[30] American planners quickly discovered that effective escort on long-range bombing missions was essential. When P-38s escorted B-17s on bombing missions to Tunisia, losses were minimal; however, when escort was not possible, such as the Schweinfurt raids and the "Black Thursday" mission, the bombers took devastating losses.[31] These lessons drove the need, in part, for an effective long-range escort fighter, which arrived in the P-51 Mustang.

The Mustang was the classic fighter-bomber of WWII; its sleek lines and bubble canopy evoke recollections of air-to-air combat and strafing Nazi locomotives. Planners initially designed it as a reconnaissance platform; however, it was significantly underpowered, so the Americans wrote it off.[32] The British installed a Rolls-Royce Merlin engine, which gave it the best range and performance of any fighter in the war; the Americans reconsidered and acquired several P-51 variants as their premier front-line fighter.[33] The A-36, an air-to-ground dive-bomber version of the P-51, saw service as an effective CAS platform in Sicily, although the lack of effective CAS coordination, communication, and integration led to many friendly fire incidents.[34] Planners initially intended to replace the P-40 with the P-51 in the Mediterranean; however, once leadership saw the utility of the P-51 in an escort role, they swapped the ETO P-

[28] Rein, *North African Air Campaign*, 66, 77, 102, 117, 124, 213.
[29] Ibid., 216.
[30] Ibid., 117-118, 124.
[31] Ibid., 76-77, 102.
[32] Hallion, *Strike from the Sky*, 51, 189; Ibid., 76, 79, 217.
[33] Hallion, *Strike from the Sky*, 51, 188-189; Rein, *North African Air Campaign*, 76, 79, 217.
[34] Hallion, *Strike from the Sky*, 177-178, 188-189; Rein, *North African Air Campaign*, 76, 79, 155, 217.

47s for the P-51s.[35] The P-51 had an airspeed and maneuverability edge over the German fighters throughout its entire flight envelope.[36]

Designers planned the P-47 Thunderbolt as an interceptor; however, the USAAF used them as escort fighters in the ETO when the P-38s went to North Africa.[37] While it was initially only effective against German fighters at high altitudes, several modifications gave it performance on par with the Fw-190 and Me-109 at virtually all altitudes.[38] Its biggest disadvantage was fuel inefficiency; it could not escort heavy bombers on long-range missions, relegating it to primarily CAS and BAI missions once the P-51s arrived.[39] In every theater, the P-47s were extremely effective in the ground support role because their rugged platform could carry up to 2,000 pounds of ordnance, in addition to their eight .50 caliber machine guns.[40]

France and Germany

Starting in mid-1943, Britain-based P-38, P-47, and, eventually, P-51 fighters focused on bomber escort missions and the devastation of the Luftwaffe fighter forces from the air in an effort to gain air superiority for D-Day. However, by April 1944, escort fighters routinely strafed airfields once the escort mission was complete, contributing to the demise of the Luftwaffe.[41] The Allies' bombing and tactical airpower campaign resulted in virtual air supremacy by the end of August 1944.[42] Mustangs led the tactical attrition of German fighter "frontline strength" between January and June 1944.[43]

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[35] Hallion, *Strike from the Sky*, 188-189; Rein, *North African Air Campaign*, 155.
[36] Benjamin Franklin Cooling, *Case Studies in the Achievement of Air Superiority* (Washington D.C.: Center for Air Force History, 1994), 277.
[37] Rein, *North African Air Campaign*, 213.
[38] Cooling, *Air Superiority*, 277-278.
[39] Ibid., 277.
[40] Benjamin Franklin Cooling, *Case Studies in the Development of Close Air Support* (Washington D.C.: Office of Air Force History, 1990), 212, 247-251.
[41] Cooling, *Air Superiority*, 290.
[42] Ibid., 272.
[43] Ibid.

> [T]he Luftwaffe was effectively destroyed...In March 1944, fully *56 percent* of the available German fighters were lost, dipping to 43 percent in April...and rising again to just over 50 percent in May...[T]he Luftwaffe's cursory D-day contribution to defending Normandy from the Allied invasion amounted to less than a hundred sorties.[44]

In April 1944, Ninth Fighter Command in Europe began a concerted tactical airpower interdiction campaign to assist in Overlord preparations.[45] However, General Elwood "Pete" Quesada's units had to spend two weeks in May testing a variety of delivery methods in order to determine the most effective air-to-ground employment procedures.[46] This lapse in air-to-ground capability stemmed from the interwar years when "'there existed a school of thought...which considered such employment uneconomical and ineffective'...the Army Air Corps had even prohibited the installation of bomb racks on fighter aircraft."[47] Quesada's fighter-bombers became markedly skilled at destroying their assigned ground targets; he eventually convinced planners to assign them high priority missions against bridges along the Seine and Loire rivers, much to the chagrin of the medium and heavy bombers.[48] By D-Day, fighter-bombers were primarily responsible for the fact that "not a single railroad bridge crossed the Seine and virtually all roadways above the river had sustained serious damage...Even Tooey Spaatz [a strategic bomber zealot] admitted that the attacks had 'opened the door for the invasion.'"[49]

After the Normandy invasion, fighter-bombers continued escort, interdiction, and CAS missions for the remainder of the war. One of Robin Olds' post-invasion interdiction sorties is the model example of a multi-role fighter's potential. Olds maneuvered to defeat ground fire, destroyed a strategic bridge at Chalon-sur-Saône with two 1,000-pound bombs, and shot down

[44] Hallion, *Strike from the Sky*, 189-190.
[45] Hughes, *Over Lord*, 124-127. Ninth Fighter Command contained 13 P-47 groups, two P-51 groups, and three P-38 groups (Ibid., 124).
[46] Ibid., 124-129.
[47] Rein, *North African Air Campaign*, 58.
[48] Hughes, *Over Lord*, 130.
[49] Ibid., 131.

two Fw-190s on the egress.[50] Quesada's fighter-bombers outperformed medium and heavy bombers by precise coordination and employment, which "helped to legitimize a mythical notion of air power that profoundly influenced close air support policy for the rest of the war."[51] These experiences confirmed the necessity of fighters in an air superiority role, as well as fighter-bombers in a high threat battlefield environment. Attack aircraft "lacked the quickness [and] ease of response...of the fighters," and proved incapable of defending themselves from enemy fighter attack.[52] Despite the rhetoric of the dive-bomber during the interwar years, by the end of the war arguments for specialized "attack aircraft" had disappeared.[53]

The Pacific Theater

The evolution of the fighter-bomber in the Pacific Theater mirrored that of the ETO and North Africa. The P-38 "became the backbone of Allied fighter strength in the Southwest Pacific for most of the remainder of the war."[54] It was the primary bomber escort, where it achieved superior kill ratios over the Japanese and attained localized air superiority.[55] While the P-47 needed drop tanks to achieve sufficient range, it "proved to be a valuable addition to the fighter inventory" in both air and ground support roles.[56] During the fight for Luzon, the largest land battle in the Pacific, fighter-bombers, including the P-51, flew 90 percent of the ground support sorties.[57] In early 1945, the P-51s began escorting B-29s on bombing raids to mainland Japan.[58] According to Japanese records, the P-51s were so effective in countering the Japanese

[50] Christina Olds and Ed Rasimus, *Fighter Pilot: The Memoirs of Legendary Ace Robin Olds* (New York: St. Martin's Griffin, 2010), 81-85.
[51] Hughes, *Over Lord*, 226.
[52] Hallion, *Strike from the Sky*, 224.
[53] Ibid., 225.
[54] Cooling, *Air Superiority*, 339.
[55] Ibid., 346, 351.
[56] Ibid., 352.
[57] Cooling, *Close Air Support*, 323-325.
[58] Cooling, *Air Superiority*, 422.

fighter opposition the "B-29s could dare to conduct medium-altitude raids in the daytime."[59] "It was the feeling of IJNAF pilots that the ZEKE fighter was about equal to the Curtiss P-40," but "found [it] nearly impossible to shake the P-51s."[60]

World War Two Conclusion and Lessons Learned

While the U.S. fighter-bombers maintained a substantial quantitative advantage over Germany and Japan, their qualitative advantage proved more decisive in the air-to-air arena, especially when one considers the P-51 Mustang. U.S. fighters became fighter-bombers out of necessity; the medium bombers could not survive, and were not accurate enough, in a battlefield support and interdiction role at low altitude. This is not to suggest that fighter-bombers did not suffer losses; in a two-week period following D-Day, ground fire was responsible for 73 to 90 percent of the 80 fighter aircraft lost.[61] However, in light of WWII as a whole, "the fighter-bomber proved overwhelmingly more valuable in supporting and attacking ground forces in the battle area than did the heavy or even medium bomber."[62]

FM 100-20, released in July 1943 as a response to lessons learned in North Africa, summarized the lessons from the beginning of the war; the most important lesson was that successful land operations required air-superiority.[63] Furthermore, bombers were not as survivable as had been predicted in the interwar years, so effective fighter escort was necessary. While it is difficult to quantify the fighter-bomber contribution to strategic war goals, "there was never any doubt that, thanks to their agility and their ability to operate at low altitudes, fighter-

[59] Ibid., 423.
[60] Ibid., 425.
[61] Hallion, *Strike From the Sky*, 225.
[62] Ibid., 196.
[63] *War Department Field Manual FM 100-20: Command Employment of Air Power* (Washington D.C.: United States Government Printing Office, 1943), http://www.au.af.mil/au/awc/awcgate/documents/fm100-20_jul_1943.pdf.

bombers could deliver ordnance much more accurately than bombers could."[64] They were extremely effective in destroying stationary and moving targets in an open field, beach, or airfield, as well as bridges, tanks, and infantry.[65]

> Fighter-bomber tactics evolved to the point where, by war's end, the less maneuverable and more vulnerable dive-bomber, which had dominated the war's opening stages, was obsolete. Further fighter designs emphasized aircraft that could perform both roles, and existing fighter aircraft...were adapted to this role.[66]

The lesson of WWII air combat was clear; fighters needed the ability to out climb and out dive the enemy, be more maneuverable than the adversary, have an airframe that could withstand battle damage, and have sufficient range to provide escort deep into enemy territory. The lesson from air-to-ground operations was that all fighters could perform air-to-ground with the right training, but not all fighter-bombers were effective in air-to-air.

The Korean War

The Korean War ushered in the transition of jet fighter to jet fighter-bomber, just as WWII did for the propeller-driven aircraft. At the outset of the war, F-80s and F-84s, designed as fighters, flew air superiority missions alongside P-51s (re-designated F-51s).[67] The initial air threat was WWII-era Soviet fighters such as the Yak-9, which had similar performance to the P-39; the pilots of these aircraft were inexperienced, and neither proved a match for the jets or Mustangs.[68] Accordingly, USAF aircraft enjoyed relative air superiority as the B-26s and fighter-bombers "destroyed most of the NKAF on the ground."[69] F-51s also conducted CAS and

[64] Martin Van Creveld, *The Age of Airpower* (New York: Public Affairs, 2011), 145.
[65] Ibid., 145-146.
[66] Rein, *North African Air Campaign*, 58.
[67] John Darrell Sherwood, *Officers in Flight Suits: The Story of American Air Force Fighter Pilots in the Korean War* (New York: New York University Press, 1996), 62, 170-171.
[68] Ibid., 73-74.
[69] Ibid., 74.

interdiction missions; however, "[o]ne lucky shot in the radiator could bring the plane down."[70] Planners reconfigured F-80s and F-84s as fighter-bombers for air-to-ground operations; drop tanks helped extend the F-80s poor range.[71] The F-80 became a lethal fighter-bomber, especially on armed reconnaissance missions, as was evidenced by a 10 July 1950 mission in Pyeongtaek when a flight of F-80s destroyed "117 trucks, seven half-tracks, and thirty-eight tanks."[72] Planners never imagined the F-80 as a multi-role fighter; however, operational necessity forced modifications for air-to-ground operations.[73]

In November 1950, the Mikoyan-Gurevich (MiG) -15 entered the air war and quickly outclassed the F-51, F-80, and F-84 with its superior speed and maneuverability.[74] The F-86, ironically designed as a fighter-bomber, was the only fighter capable of challenging the MiG-15's instantaneous air superiority.[75] Although the MiG-15 had a ceiling and speed advantage, the F-86 was more maneuverable and had a radar-computed gun sight, an armored cockpit with bulletproof glass, and more experienced pilots.[76] For this reason, most MiGs were "reluctant to 'mix it up'" with the Sabres.[77] Because of their air superiority role, the F-86s did not perform multi-role missions until February 1953 where their bombing was just as accurate as the slower jets.[78] Despite its limited air-to-ground experience, Fifth Air Force "considered the Sabre the

[70] Conrad C. Crane, *American Airpower Strategy in Korea* (Kansas: University Press of Kansas, 2000), 26.
[71] Sherwood, *Officers in Flight Suits*, 170-171.
[72] Ibid., 171-172.
[73] Ibid., 170-171.
[74] Crane, *American Airpower Strategy in Korea*, 48-49; Sherwood, *Officers in Flight Suits*, 2, 18-19, 62.
[75] Cooling, *Air Superiority*, 489.; Crane, *American Airpower Strategy in Korea*, 68; Sherwood, *Officers in Flight Suits*, 74-75.
[76] Crane, *American Airpower Strategy in Korea*, 89; Sherwood, *Officers in Flight Suits*, 74-75; Cooling, *Air Superiority*, 468.
[77] Sherwood, *Officers in Flight Suits*, 84; Cooling, *Air Superiority*, 470.
[78] Crane, *American Airpower Strategy in Korea*, 162.

most suitable fighter-bomber for the theater, mainly because its speed [and maneuverability] gave it an ability to survive enemy defenses superior to that of any other USAF fighter."[79]

General Otto Weyland, Commander of Far East Air Forces (FEAF), stated, "The outstanding air-combat lesson of the Korean War was learned during the first few days of the conflict—namely that superior performance is the first and essential requirement of [fighter] aircraft in modern war."[80] Despite its design as a fighter-bomber, the F-86 airframe was more effective at air combat than the "pure" fighters were. This disparity arose from a general misunderstanding of jet aircraft flight characteristics in the mid-1940s when the F-80 and F-84 were designed, which engineers resolved for the F-86 design. Unfortunately, the USAF viewed future fighters as a platform for tactical nuclear delivery and bomber interdiction, which ushered in an era of fighters unsuited for air-to-air, and by extension air-to-ground, combat.[81]

The Vietnam War

General Weyland, as the Commander of Tactical Air Command (TAC), adopted tactical nuclear delivery and bomber intercept missions in the face of absorption by Strategic Air Command (SAC); this strategy necessitated a shift away from the combined-arms and aircraft design lessons learned in the previous three wars.[82] The USAF's procurement of the "Century Series" aircraft, the F-100 through 106, demonstrated a failure to design effective air-to-air and multi-role fighters.[83] These aircraft were "inferior in the air-superiority role," mostly due to their poor maneuverability.[84] Interceptor design centered on achieving high altitude and

[79] Ibid.
[80] Ibid., 172.
[81] Ibid.
[82] John Schlight, *Help from Above: Air Force Close Air Support of the Army 1946-1973 (*Washington D.C.: Air Force History and Museums Program, 2003), 182.
[83] Craig C. Hannah, *Striving for Air Superiority: The Tactical Air Command in Vietnam* (Texas: Texas A&M University Press, 2002), 31, 47; Cooling, *Air Superiority*, 526.
[84] Hannah, *Striving for Air Superiority*, 31.

supersonic speeds to intercept enemy nuclear bombers; designers sacrificed maneuverability "to reduce wave drag at supersonic speeds," and because pilots do not need maneuverability to shoot down heavy bombers.[85] Subsequently, none of these aircraft was maneuverable enough to dogfight, and several did not even have an internal cannon, indicative of their faith in missile technology. Design engineers had complete confidence that air-to-air missiles rendered dogfights, where maneuverability and visibility were paramount, obsolete; they believed the air combat of the future would be beyond visual range (BVR).[86]

Republic F-105 Thunderchief, Nickname "Thud"

Planners designed the F-105 as a supersonic, tactical nuclear-delivery fighter-bomber with an internal cannon; it could also carry internal and external air-to-ground ordnance as well as air-to-air missiles.[87] In an air-to-air engagement, it relied on its missiles for a kill, or an undetected entry to a gun shot, instead of a maneuvering engagement.[88] One Air Force historian noted, "Air planners considered the plane's inability to dogfight irrelevant. They contended...air-superiority missions would guarantee the Thunderchief a safe environment."[89] In Vietnam, if enemy fighters targeted the F-105 prior to the target area, they jettisoned their bombs and ran instead of engaging the MiGs; once off target, they had to fight their way out. Despite these drawbacks, the F-105 achieved 27.5 air-to-air victories over the course of the war—25 were gun kills; however, MiGs shot down 22 Thuds, an unacceptable 1.25:1 kill ratio.[90] The Thud was not an effective air-to-air fighter; however, its 6,000-pound bomb load made it a credible, if

[85] Ibid., 46-47.
[86] Ibid., 55.
[87] Cooling, *Air Superiority*, 526; Hannah, *Striving for Air Superiority*, 51-52; Schlight, *Help from Above*, 187.
[88] Hannah, *Striving for Air Superiority*, 51-52.
[89] Ibid., 51.
[90] Kenneth P. Werrel, *Chasing the Silver Bullet: U.S. Air Force Weapons Development from Vietnam to Desert Storm* (Washington D.C.: Smithsonian Books, 2003), 13; Hannah, *Striving for Air Superiority*, 51.

inaccurate, bomber.[91] Its size, maneuverability, and speed, compared to traditional bombers such as the B-52, made it more survivable than the heavy bombers in the surface-to-air missile (SAM) missile engagement zones (MEZ) that overlapped the target areas.[92] Planners modified two-seat F-105s to provide Suppression and Destruction of Enemy Air Defenses (SEAD and DEAD) capability to the large strike packages that routinely entered MEZs, since the F-100F proved insufficient to counter the SAM threat alone.[93] This dangerous game resulted in 54 Thuds lost in 1966 and 103 in 1967; the F-105 retired from strike duty before the end of the war, but continued the invaluable Wild Weasel mission.[94] The Thud flew 157,895 sorties, 53.8 percent "were to the most heavily defended targets in North Vietnam;" consequently, it suffered the highest combat losses of fixed-wing aircraft in the Vietnam War.[95]

McDonnell Douglas F-4 Phantom II

The lack of an air superiority fighter, as well as pressure from political leadership for the USAF and United States Navy (USN) to "purchase the same aircraft types," led the USAF to buy the Navy's F-4, originally designed as an interceptor for fleet defense.[96] While the Phantom's payload was impressive, eight air-to-air missiles and two tanks of gas for an air-to-air mission or four air-to-air missiles and 16,000 pounds of bombs, pods, and fuel tanks for an air-to-ground mission, its air-to-air limitations were significant in a dogfight.[97] The F-4 design also "proclaimed that the day of the dogfight was over."[98] Between May 1972 and January 1973, 321

[91] Schlight, *Help from Above*, 49; Werrell, *Chasing the Silver Bullet*, 11.
[92] Van Creveld, *The Age of Airpower*, 390.
[93] Anthony M. Thornborough and Frank B. Mormillo, *Iron Hand: Smashing the Enemy's Air Defences* (England: Patrick Stephens Limited, 2002), 47, 88. Evolution of USAF Wild Weasel aircraft: F-100F, F-105D/F/G, F-4C/E/G, and F-16CJ (Ibid., 42-66, 84-98, 149-174, 193-222, 255-282).
[94] Ibid., 59.
[95] Hannah, *Striving for Air Superiority*, 47-48.
[96] Ibid., 54.
[97] Ibid., 55-58;, C.R. Anderegg, *Sierra Hotel: Flying Air Force Fighters in the Decade After Vietnam* (Washington D.C.: Air Force History and Museums Program, 2001), 9-14.
[98] Anderegg, *Sierra Hotel*, 10.

missiles resulted in 33 kills, a 10.3 percent kill rate.[99] The actual missile probability of kill (P_k) in Vietnam is somewhat higher due to trigger-happy pilots and the failure of delicate electronics; either way, missile technology did not render the dogfight obsolete.[100]

Another Phantom design flaw was its lack of a cannon; after pilot complaints, it finally received an external gun pod in 1967.[101] Eventually, designers added an internal cannon to the F-4E, which shot down seven enemy MiGs during fourteen attempts.[102] Another deficiency was poor cockpit visibility. "Since the days of Baron von Richthofen and Eddie Rickenbacker, most fighter attacks have been from the rear of the aircraft where an unwary pilot had no idea that he was about to be attacked...poor visibility was and will always be an unforgivable sin in fighter aircraft design."[103] The list of problems contributing to poor air-to-air employment was long: smoking engines, poor radios, susceptibility to departure from controlled flight, and cumbersome cockpit switch layout and activation.[104] Although the F-4 had a better thrust-to-weight ratio than every other fighter, it was not maneuverable enough to dogfight with the agile MiGs.[105] The USAF F-4 had a 3:1 kill ratio, very different from the 7:1 ratio of the Korean War gunfighters.[106]

The Phantom's speed and design forced it to drop bombs from higher altitudes, reducing accuracy when compared to slower airplanes, such as the A-1 and F-100.[107] The F-105 and F-4's bombs had a circular error of probability (CEP), or "radius...within which half of all the weapons targeted for the center of that circle can be expected to land," of 323 feet.[108] When a 500-pound

[99] Cooling, *Air Superiority*, 554.
[100] Hannah, *Striving for Air Superiority*, 60-61; Anderegg, *Sierra Hotel*, 11.
[101] Hannah, *Striving for Air Superiority*, 57-61.
[102] Ibid., 62-63; Cooling, *Air Superiority*, 554.
[103] Hannah, *Striving for Air Superiority*, 55.
[104] Ibid., 55-65.
[105] Ibid., 65.
[106] Ibid., 98; Xiaoming Zhang, *Red Wings Over the Yalu: China, The Soviet Union, and The Air War in Korea* (Texas: Texas A&M University Press, 2007), 5.
[107] Schlight, *Help From Above*, 310-311; Anderegg, *Sierra Hotel*, 5.
[108] Anderegg, *Sierra Hotel*, 5.

bomb must hit within 25 feet of a truck to destroy it, accuracy is important.[109] The Thud and Phantom made up for their inaccuracy by dropping more bombs.[110] A typical mission against a single bridge, before Precision Guided Munitions (PGMs), could include 48 fighter-bombers with 576 total bombs, and there was a 50 percent chance "the bridge would still stand."[111] Despite these limitations, the Phantom was TAC's fighter-bomber workhorse in Southeast Asia; the late addition of PGMs increased its effectiveness as a bomber. The F-4 was not limited to traditional fighter-bomber roles; it also picked up the Wild Weasel (SEAD) mission, where it performed commendably in combat from 1970 through Desert Storm.[112]

General Dynamics F-111 Aardvark

The F-111 represented another TAC effort to integrate with SAC, while maintaining an effective fighter-bomber force. In order to incorporate air-to-air aspects into this fighter-bomber, the Air Force planned to "use sophisticated radar and be equipped with advanced air-to-air missiles...this aircraft would be on the cutting edge of technology in a number of areas."[113] The resulting F-111 was heavy, underpowered, and not maneuverable enough for multi-role operations; or as one Air Force general remarked, the F-111 was "too complicated, too big, too expensive, too many things."[114] The F-111's 1968 combat debut was a disaster; design failures caused three aircraft to crash.[115] On one mission, 55 aircraft reached the target area, the 31 aircraft that did not miss the target "achieved an average error of 1,050 feet."[116] The F-111 completed its Air Force service as a strike aircraft and Electronic Warfare (EW) aircraft in support of combat operations in Desert Storm, where ironically it achieved its only reported air-

[109] Ibid.
[110] Ibid., 8.
[111] Ibid.
[112] Thornborough, *Iron Hand*, 94-96.
[113] Werrell, *Chasing the Silver Bullet*, 24-25.
[114] Ibid., 28.
[115] Ibid., 28-29.
[116] Ibid., 29.

to-air kill. An Iraqi Mirage F-1 attempted to follow an EF-111 during its low-level terrain masking and crashed into a mountain.

Vietnam War Conclusion and Lessons Learned

When Weyland retired in 1959, he predicted, "[P]reoccupation with strategic bombing and missiles would 'leave us unprepared to fight [conventional] war.'"[117] The inherent limitations in the basic design of Vietnam-era fighter-bombers resigned them to mediocre performance.[118] In the 1,577 U.S. air-to-air engagements, 22.9 percent used the gun and 28.8 percent used AIM-9s; these within visual range (WVR) employment numbers demonstrate that more than 50 percent of engagements involved some sort air combat maneuvering.[119] An overreliance on missile and fighter radar technology, led to a fighter design that was incapable of dogfighting with enemy aircraft. The unacceptable 2:1 air-to-air kill ratio in Vietnam, the re-emergence of the dogfight, and the severe fighter-bomber losses to SAMs and anti-aircraft artillery (AAA), led the USAF to rethink its fighter acquisition programs in the years leading up to Desert Storm.[120]

The Eagle and the Viper

Since the release of FM 100-20, air superiority has been *the* mission, and the theoretical doctrinal focus, of the USAF; WWII and the Korean War displayed the capabilities of a superior air-to-air fighter, while Vietnam left fighter pilots clamoring for a fighter that could "win in the unforgiving arena of air combat."[121] Pilots wanted a fighter that was superior to their enemy's; they craved "more thrust, improved maneuverability, perfect cockpit visibility, a powerful radar,

[117] Schlight, *Help From Above*, 185.
[118] Werrell, *Chasing the Silver Bullet*, 15.
[119] Ibid., 42, 45. Modern WVR is considered <5NM; BVR is >5NM. AIM-9s are a WVR, infrared (IR) missile.
[120] Hannah, *Striving for Air Superiority*, 105. The USAF lost 1,606 aircraft in SE Asia between 1962 and 1973; 66 (4.1 percent) were lost to MiGs, while 1,267 (78.9 percent) were lost to some form of fire from the ground (Small Arms (SA)/Automatic Weapons (AW), AAA, or SAMs) (Ibid., 73).
[121] Anderegg, *Sierra Hotel*, 149.

long-range missiles, an internal gun, cockpit switches that were easy to find, and the sole mission of air superiority—no bombs."[122]

McDonnell Douglas F-15A/B/C/D Eagle and F-15E Strike Eagle

The F-15 Eagle was the first true air superiority fighter since the P-51 and the F-86. However, it grew from the F-X program, another Cold War-style fighter-bomber—heavy, fast, large payload, multi-role, reliant on radar and missile technology, not maneuverable in a dogfight, and expensive; essentially another F-111.[123] The experiences of Vietnam helped Air Force leadership to refocus the program on air superiority, leading to the mantra, "not a pound for air-to-ground."[124] The A-7, another Navy aircraft purchased by the USAF, also helped shape the future of the F-15; its slow speed and attack role made a fighter escort mandatory.[125] According to air power theorist John Boyd, when the USAF purchased the A-7 as its air-to-ground platform, the F-X's primary requirement changed to air superiority.[126] Regardless of the impetus for change, planners designed the F-15 as a pure air superiority fighter. Its BVR capability relied on a powerful radar and payload of eight air-to-air missiles; its thrust, visibility, and maneuverability gave it unmatched performance in a dogfight.[127]

Although Air Force planners did not want an air-to-ground version of the Eagle, McDonnell Douglas invested its own money in the design and test of a multi-role Eagle, which ultimately won in a fly off against a modified F-16 in 1984.[128] The resulting F-15E Strike Eagle has the BVR performance of the F-15C and a somewhat diminished WVR maneuverability due

[122] Ibid.
[123] Werrell, *Chasing the Silver Bullet*, 57-61; Hannah, *Striving for Air Superiority*, 106-108.
[124] Werrell, *Chasing the Silver Bullet*, 62-63.
[125] Hannah, *Striving for Air Superiority*, 106-107.
[126] Ibid., 107.
[127] In its initial operational testing against a variety of other Major Weapon Systems (MWS), such as the A-4, F-5, F-106, A-37, and F-4E (with enhanced maneuvering characteristics), the Eagle dominated all of them with a kill ratio of 88:1. In 202 engagements, the F-4E was the only aircraft able to maneuver to a Weapons Engagement Zone (WEZ) and employ ordnance—and it only happened twice (Ibid., 111).
[128] Werrell, *Chasing the Silver Bullet*, 74-75.

to conformal fuel tanks, air-to-ground ordnance, and pods. However, its air-to-ground capabilities include a ground mapping radar and 24,500 pounds of air-to-ground ordnance, from dumb bombs to a variety of USAF PGMs.[129] This transformation demonstrates the evolution of proven fighter design and technology into an effective multi-role platform.

General Dynamics (Lockheed Martin) F-16 Fighting Falcon, Nickname "Viper"

Around the same time that the F-X program was about to become the "son of the F-111," Boyd and his "Fighter Mafia" fought against the procurement of another fighter-bomber incapable of dogfighting; the result of their efforts was the Lightweight Fighter (LWF) program. Boyd's Mafia designed the LWF to be a small, highly maneuverable, day only, dogfight-optimized fighter; the low unit cost of these fighters would permit the USAF to buy a large number to complement the Eagle in the proposed high-low mix.[130] The design emphasized "superior maneuvering performance and handling qualities" in the regimes necessary for dogfighting.[131] A number of players affected the design and acceptance of the F-16 program. The USAF did not want senior political and military leadership to impose naval aircraft designs, as it had with the F-4 and the A-7.[132] While the Secretary of Defense wanted a fighter acquisition process that addressed cost and performance issues with programs such as the F-111; "[t]he lure of standardizing NATO aircraft, as well as earning profits overseas propelled the F-16 above the normal Air Force and defense politics."[133] General Dynamics' YF-16 outperformed

[129] Ibid., 74-76; James P. Coyne, *Airpower in the Gulf* (The Air Force Association, 1992), 74. Like virtually every other fighter program, the Eagle has undergone multiple upgrades; from the "A/B" to the "C/D" model, it received better avionics, more thrust, more maneuverability, improved radar and radar-warning receiver, and the AIM-120 AMRAAM, a true BVR fire-and-forget missile.
[130] Werrell, *Chasing the Silver Bullet*, 59. An Air Staff study prior to this time recommended a small force of capable, expensive fighters, as well as a larger number of "new low-cost aircraft," in a strategy known as the "high-low mix"—the F-15/F-16 was the result. (Ibid., 61).
[131] Jacob Neufeld, George M. Watson Jr., and David Chenoweth, *Technology and the Air Force: A Retrospective Assessment* (Washington D.C.: Air Force History and Museums Program, 1997), 210.
[132] Werrell, *Chasing the Silver Bullet*, 79.
[133] Ibid.

Northrop's YF-17 in maneuverability, acceleration, range, visibility, and virtually every other air-to-air aspect, with the exception of its angle of attack (AoA).[134] Today's F-16 bears little resemblance to Boyd's LWF, most importantly in its multi-role capability. The USAF added capabilities and mission sets to the F-16, to include SEAD, Forward Air Controller-Airborne (FAC-(A)), reconnaissance, and every air-to-air and air-to-ground mission.[135] Despite these modifications into the USAF-mandated fighter-bomber, the Viper maintained its inherent superb dogfighting capability. In a dogfight, it "had the edge over the F-15 and a significant advantage over everything else...The F-16 was a superb gunfighter, and in the furball it was the top cat."[136]

Desert Storm

Desert Storm represents the pinnacle of conventional US airpower in the 20th century; all of the lessons learned and re-learned over the years enhanced the design of the weapons and aircraft employed in this war.[137] F-15Cs performed air superiority missions throughout the war, where they achieved 33 of the coalition's 38 air-to-air kills.[138] Sixteen of the 38 kills were BVR; the remainders were WVR, where a potential for combat maneuvering existed.[139] The Strike Eagle's air-to-ground payload, and night navigation and targeting systems, made it lethal against Scuds, armor, and virtually any other target.[140] At night, the F-15Es surprised Iraqi airfields by arriving overhead at 300 feet and simultaneously hitting targets; by the time the Iraqis started

[134] Ibid., 85-86, 91-92. Angle of Attack is the angle measured from an imaginary line connecting the leading and trailing edge of the wings to the flight path of the aircraft. An aircraft that can fly at a higher AoA and lower airspeed than his adversary has the ability to point his aircraft (to employ ordnance) when his adversary can no longer sustain controlled flight.
[135] A FAC-(A) is a uniquely qualified pilot to direct and control other fighter aircraft in a CAS environment.
[136] Anderegg, *Sierra Hotel*, 179.
[137] The F-4 and F-111 fought in this conflict; however, they did not participate in their original airframe-designed role. The F-4G executed the SEAD mission, and the RF-4C performed reconnaissance missions. The F-111 executed surface attack and interdiction missions, and the EF-111 performed Electronic Attack (EA).
[138] Werrell, *Chasing the Silver Bullet*, 244.
[139] Ibid.
[140] Coyne, *Airpower in the Gulf*, 74-75.

firing, the Strike Eagles were gone.[141] The F-15Es received the limited number of targeting pods and LGBs for Scud hunting missions.[142] The failed Scud hunts were due more to intelligence gaps and the difficulty in finding a mobile launcher than a platform issue.[143]

Early in the war, Vipers destroyed SAM sites and AAA gun emplacements.[144] They also destroyed Iraqi supply and transportation lines during armed reconnaissance missions; "by the third week in February [1991], resupply movements were largely restricted to the night hours, as Iraqi vehicles sought refuge in the darkness."[145] However, surface-to-air fire drove Vipers to employ dumb bombs from a higher altitude, making them less accurate with a combat CEP of 200 feet.[146] Subsequently, a typical strike mission consisted of 16 escort F-15Cs, 32 strike F-16s, eight F-4G Wild Weasels, four EF-111 EW platforms, plus aerial refueling.[147] Vipers flew 13,087 sorties where they "played a key role in the destruction of the Iraqi forces in Kuwait and Iraq."[148] Although no USAF multi-role fighters shot down any enemy fighters, fighter-bomber operations were crucial to the war's success.[149]

It is difficult to place a strategic value on tactical aviation. One indicator of value is international opinion; 28 customers worldwide bought more than 4,500 F-16s, many since Desert Storm. [150] Additionally, Korea, Singapore, Saudi Arabia, and Israel all purchased F-15E

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[141] Ibid., 75.
[142] Ibid.
[143] Ibid., 55-56; Werrell, *Chasing the Silver Bullet*, 277.
[144] Coyne, *Airpower in the Gulf*, 50.
[145] Thomas A. Keaney and Eliot A. Cohen, *Gulf War Air Power Survey Summary Report* (Washington D.C., 1993), 97.
[146] Werrell, *Chasing the Silver Bullet*, 254, 278; Anderegg, *Sierra Hotel*, 5. Viper peacetime, low altitude bombing accuracy was 30 feet; Vietnam fighter-bomber accuracy was 323 feet (Werrell, *Chasing the Silver Bullet*, 254; Anderegg, *Sierra Hotel*, 5.).
[147] Rick Atkinson, *Crusade: The Untold Story of the Persian Gulf War* (New York: Houghton Mifflin Company, 1993), 66.
[148] Keaney, *Gulf War Air Power Survey Summary Report*, 184; Coyne, *Airpower in the Gulf*, 50. As a comparison, the F-15C flew 5,685 sorties, the F-15E flew 2,172 sorties, and the F-4G flew 2,683 sorties (Keaney, *Gulf War Air Power Survey Summary Report*, 184).
[149] Werrell, *Chasing the Silver Bullet*, 244. Navy multi-role F/A-18s shot down two enemy aircraft (Ibid.).
[150] Lockheed Martin, *F-16 Fighting Falcon Overview*, http://www.lockheedmartin.com/us/products/f16.html.

derivatives for their air superiority and strike requirements.[151] Popular opinion indicates the perceived value of the F-16 and F-15E as multi-role fighters. It is also challenging to place a value on the effectiveness of the F-15C against inferior aircraft and pilots; however, "the ultimate measure of a military is how it performs its designated mission," and the results speak for themselves.[152] In every air war, enemy surface-to-air fire, accounts for the most aircraft losses. In Desert Storm, the Iraqi Integrated Air Defense System (IADS) was significant: 380 AAA batteries, 26 SA2s and 3s, eight SA-6s, 15 SA-8s, and nine Rolands.[153] However, only "[f]ourteen USAF aircraft were shot down by SAMs, AAA, or ground fire;" two were F-15Es, and three were F-16s.[154] SEAD and EW assets assisted in the coalition survival in the MEZ; however, individual fighter-bomber SAM/AAA threat reactions also contributed to their survival.[155] Fighter-bombers' inherent maneuverability, visibility (to see the threat), and acceleration (to maintain and regain speed crucial in threat reactions) were vital to their survival.

Desert Storm lessons confirmed the benefits of air superiority and of the *right* technology such as low observable (LO) aircraft, *operational* missile technology, and PGMs. Missile technology, such as the AIM-7F and the High-Speed Anti-Radiation Missile (HARM), proved effective missile technology was feasible, which paved the way for the Advanced Medium-Range Air-to-Air Missile (AMRAAM) and air-to-ground standoff munitions. PGMs comprised 8 percent of the air-to-ground munitions employed in the war at 40.8 percent of the cost; 85 percent of the LGBs hit within ten feet of the desired impact point.[156] Mature technology does

[151] Boeing, *F-15E Strike Eagle Overview*, http://www.boeing.com/assets/pdf/defense-space/military/f15/docs/F-15SE_overview.pdf.
[152] Werrell, *Chasing the Silver Bullet*, 244, 276-277.
[153] Thornborough, *Iron Hand*, 194.
[154] Coyne, *Airpower in the Gulf*, 104; Werrell, *Chasing the Silver Bullet*, 254-255.
[155] Thornborough, *Iron Hand*, 199. Of the five aircraft shot down by radar guided SAMs, four did not have SEAD support, proving its importance during a high-threat mission (Coyne, *Airpower in the Gulf*, 104; Werrell, *Chasing the Silver Bullet*, 254-255).
[156] Werrell, *Chasing the Silver Bullet*, 258-259.

not render multi-role fighters obsolete; it simply adds mission sets and capabilities to airframes that may not have capacity for growth. However, the combat test of Desert Storm validated air superiority as the first design priority, and confirmed the best multi-role fighter designs as an evolution of single role air-to-air fighters.

Post Desert Storm

As of 2002, the Eagle had achieved an unprecedented combat kill ratio of 95:0, including U.S., Israeli, and the Royal Saudi Air Forces.[157] Although some argue that Desert Storm was the genesis of true BVR missiles, subsequently rendering dogfights obsolete...again, the missile P_k tell a different story. The overall BVR success of the U.S. in Desert Storm was 18 percent (16 BVR kills over 88 "radar" missile shots); additionally, the total P_k of "radar" missiles in Desert Storm was 27.3 percent (24 kills over 88 shots).[158] The total number of post-Desert Storm air-to-air shots is not available.[159] However, in one BVR engagement on 5 January 1999, two F-15Cs fired three AIM-7s and one AIM-120 at two Iraqi MiG-25s, all four missiles missed; subsequently, two Navy F-14s fired two AIM-54 Phoenix missiles at the same two MiGs, both missiles missed.[160] The combat statistics of BVR missiles continue to support the development of fighters capable of dogfighting.

Planners have upgraded the F-15E and the F-16 multiple times to take advantage of the latest avionics, targeting systems, and weapons available. The F-15E continues to perform well in its role as a fighter-bomber, although its only air-to-air kill remains an LGB dropped on a

[157] Hannah, *Striving for Air Superiority*, 111.
[158] Lt Col Patrick Higby, *Promise and Reality: Beyond Visual Range (BVR) Air-to-Air Combat* (Maxwell AFB, AL: Air War College, 2005), 12. While LtCol Patrick Higby discusses "radar" missiles, these missiles were all Semi-Active Radar (SAR) missiles (AIM-7s)—the missile must be supported by the radar until impact. The AMRAAM is a true radar-guided missile; it does not require radar support until impact. Of note, an F-16 achieved the first combat AMRAAM kill in Operation Southern Watch in December 1992.
[159] Ibid., 14.
[160] Ibid.

helicopter during Desert Storm.[161] Strike Eagles and Vipers have deployed in support of virtually every major combat operation since Desert Storm; they have been key in the destruction of military targets, as well as in support of ground troops during CAS operations. Since Desert Storm, USAF F-16s have shot down seven enemy aircraft with zero losses.[162] In its first combat SEAD mission, F-16CJs protected Allied aircraft during Operation Allied Force; over 38,000 Allied missions and 673 SAM launches, surface-to-air fire only shot down two aircraft.[163] When opposed by enemy forces in Operations Iraqi Freedom and Odyssey Dawn, no F-16s or F-15Es were lost to enemy fire. Innovations in munitions and targeting technology have increased the lethality of these fighter-bombers; although recent conflicts are very different from Vietnam, these multi-role fighters perform exceptionally well.

5th Generation Fighter-Bombers

Lockheed Martin F-22 Raptor

In 2001, USAF Chief of Staff, General John Jumper, "identified the...Su-35 and Su-37 as air-to-air threats superior to the F-15C;" modern fighters employ Active Electronically Scanned Array (AESA) radars, long-range active radar missiles, and are highly maneuverable.[164] The Advanced Tactical Fighter (ATF) program called for an advanced air superiority fighter that could provide a significant qualitative advantage over the modern threat to the Eagle's air

[161] Coyne, *Airpower in the Gulf War*, 51.
[162] Craig Brown, *Debrief: A Complete History of U.S. Aerial Engagements – 1981 to the Present* (Pennsylvania: Schiffer Publishing Ltd., 2007).
[163] Thornborough, *Iron Hand*, 271.
[164] Lt Col Devin L. Cate, *The Air Superiority Fighter and Defense Transformation: Why DOD Requirements Demand the F/A-22 Raptor* (Maxwell AFB, AL: Air War College, 2003), 11, http://www.au.af.mil/au/awc/awcgate/maxwell/mp30.pdf; Russell D. Shaver, Edward R. Harshberger, and Natalie W. Crawford, *Modernizing Airpower Projection Capabilities: Future Needs and Options* (Santa Monica , CA: Rand Corporation, 1997), 3-5, http://www.rand.org/content/dam/rand/pubs/issue_papers/2006/IP126.pdf.

superiority.[165] The Raptor provides an extraordinary air-to-air capability at an estimated rate of 30:1 over 4th generation aircraft in high threat scenarios; its stealth, acceleration, maneuverability, avionics and sensor integration, and air-to-air payload enable it to excel "at its originally designed air-to-air mission."[166] In 1993, twelve years into the ATF program, pressure from civilian leadership led the USAF to adopt an air-to-ground capability for their air supremacy fighter.[167] The Raptor's air-to-air characteristics enable air-to-ground missions in high-threat environments where 4th generation aircraft, such as the F-16 and F-15E, cannot survive.[168] However, its highly specialized, air-to-air requirement leaves gaps in interoperability and air-to-ground capability that 4th generation fighter-bombers offer, such as a "wider variety of air-to-ground munitions" and advanced targeting pods.[169] Therefore, the F-22 cannot take the place of 4th generation fighter-bomber aircraft in conventional air-to-ground operations.

Lockheed Martin F-35 Lightning II

The tri-service, Joint Strike Fighter (JSF) program (USAF, USN, and USMC) sought a replacement to each service's 4th generation multi-role fighters; the USAF wanted a replacement for the F-16, F-15E, and A-10, even though the A-10 is a dedicated ground attack platform.[170] Planners intended to "take advantage of technological advances while reducing research, development, and procurement costs" in order to "keep...technological superiority in a period of constrained resources."[171] This attempt to keep costs low sounds reasonable, but the actual cost

[165] Lt Col Christopher J. Niemi, *The F-22 Acquisition Program: Consequences for the US Air Force's Fighter Fleet*, Air & Space Power Journal (November-December 2012): 55-56, http://www.airpower.maxwell.af.mil/digital/pdf/articles/2012-Nov-Dec/F-Niemi.pdf.
[166] Ibid., 64.
[167] Ibid., 58.
[168] Ibid., 63-65.
[169] Ibid., 65.
[170] Jeremiah Gertler, *F-35 Joint Strike Fighter (JSF) Program*, (Washington D.C.: Congressional Research Service, 2014), 2, http://www.dtic.mil/get-tr-doc/pdf?AD=ADA590244.
[171] Les Aspin, *Report on the Bottom-Up Review*, (Washington D.C.: Department of Defense, 1993), iv, http://handle.dtic.mil/100.2/ADA359953.

of the program has steadily risen to unprecedented levels. "The issue of F-35 affordability is part of a larger and long-standing issue concerning the overall affordability of DoD's tactical aircraft modernization effort."[172] If civilian leadership reduces actual JSF procurement numbers, which seems inevitable in the current fiscally constrained environment with rising JSF costs, the F-22/F-35 "high-low" mix requirements planned for air superiority will not have the mass needed to benefit from their qualitative advantage.[173] Subsequently, a fighter-bomber "never designed to go to a merge," will likely find itself outmatched in a dogfight.[174] General Hostage, former Commander of Air Combat Command (COMACC), emphasized the F-35's dependence on the air-to-air capabilities of the F-22; "If I do not keep that F-22 fleet viable, the F-35 fleet frankly will be irrelevant. The F-35 is not built as an air superiority platform. It needs the F-22."[175] By prioritizing air-to-ground design over air-to-air, reduced numbers of the F-35 will not be capable of supporting its share of the air-to-air burden.[176] F-35 advocates use terms such as "unprecedented capability," "game-changing technology," "cutting edge capabilities," and "sensor fusion" in regards to the F-35's air-to-ground and BVR air-to-air capabilities. However, "the F-35 pilot who engages in a dogfight has either made a mistake or been very unlucky;" the JSF was not designed to be "a small Raptor."[177] These comments are not meant to add fuel to the "F-35 hate;" it is merely to point out that designers *specifically* never intended the F-35 to be

[172] Gertler, *F-35 Joint Strike Fighter (JSF) Program*, 32.
[173] Civilian leadership cut the Raptor procurement to 187 aircraft (from the planned 750) due to policy and budget constraints. The planned F-35 procurement is 2,547 across three services; USAF leadership repeatedly states its requirement for all 1,763 of the planned USAF buy. (Niemi, *The F-22 Acquisition Program*, 54; Gertler, *F-35 Joint Strike Fighter (JSF) Program*, 11; Maj Michael K. Schnabel, *Can You Create the Universal Pilot for the Universal Aircraft: Will Specialization be Necessary for the Air Force F-35 Fleet?*, (Maxwell AFB, AL: Air Command Staff College, 2007), 11, http://dtlweb.au.af.mil/webclient/StreamGate?folder_id=0&dvs=1417624577309~555).
[174] ACSC Lecture by a USAF senior leader involved in the F-35 program.
[175] Aaron Mehta, "Air Combat Command's Challenge: Buy new or modernize older aircraft", Air *Force Times*, (February 2, 2014), http://www.airforcetimes.com/article/20140202/NEWS04/302020005/Air-Combat-Command-s-challenge-Buy-new-modernize-older-aircraft.
[176] Gertler, *F-35 Joint Strike Fighter (JSF) Program*, 2.
[177] Colin Clark, "Gen. Mike Hostage on the F-35; No Growlers Needed When War Starts," *Breaking Defense*, (June 6, 2014), http://breakingdefense.com/2014/06/gen-mike-hostage-on-the-f-35-no-growlers-needed-when-war-starts; ACSC Lecture by a USAF senior leader involved in the F-35 program.

an effective air superiority fighter. Requirements, forced by budget and policy restraints in a joint and international program, ensured air superiority, and by extension dogfighting, was not inherent in its design.

Conclusion

The USAF's first objective in every war since WWII is air superiority; DoD design and procurement decisions have supported that objective over the years, with a few exceptions. Air superiority is the control of the air to such an extent that land, sea, and air forces can operate with "relative freedom of movement" and expectation of safety from enemy air attack.[178] The most effective air superiority platforms also turned out to be the most effective multi-role fighters. The P-39 and P-40's air-to-air performance in WWII was inadequate; their range and maneuverability proved insufficient to continue long-term air-to-air operations, but their air-to-ground contributions were commendable. The P-47 and P-51 design addressed deficiencies in earlier fighter aircraft procurement, "and the advantage in aerial combat shifted abruptly to American pilots flying these types."[179] The F-86 is the sole fighter-bomber design in this study that excelled in air combat; however, this distinction stemmed from its intrinsic fighter characteristics and not from technological advances or air-to-ground design attributes. The F-105 and F-111 specifically demonstrated the danger of a multi-role design that relies on technology for survival and effective combat operations. These failures in fighter design helped pave the way for the modern success of the Eagle, Viper, and Raptor designs.

The Wild Weasel mission provides one positive example of the successful convergence of technology and historical lessons learned. When the SEAD mission migrated to the F-16CJ

[178] Hughes, *Over Lord*, 152.
[179] William D. White, *U.S. Tactical Air Power: Missions, Forces, and Costs*, (Washington D.C.: The Brookings Institution, 1974), 45.

after Desert Storm, critics contended the mission was too complicated for a single-seat fighter.[180] However, the Viper's inherent advantages over the F-4, such as acceleration, visibility, maneuverability, range, and loiter time, as well as technological advances with the HARM Targeting System (HTS) pod, made the F-16CJ a more lethal SEAD platform than the F-4G.[181] The HTS pod's "automated detection and classification features" handled the "beeps and squeaks" that the weapons systems officer (WSO) formerly had to manually control and identify.[182] Viper pilots could now "focus on tactics and other missions the aircraft was capable of performing...the F-16...could not only protect itself, but had the capability and trained pilots to provide such protection to others since its pilots had more room to study and practice other disciplines."[183]

The characteristics of successful multi-role fighters mimic those of successful air superiority fighters; they are extremely maneuverable and can climb and accelerate quickly with a relatively high top speed.[184] Airspeed makes weapons more lethal and permits more aggressive maneuvering. The ability to sustain speed during a high-G threat reaction allows energy preservation and maneuverability, making the fighter more survivable. Other characteristics of successful fighter-bombers, née air superiority fighters, are superior visibility, substantial payload, high ceiling, and an internal cannon.[185] While the Raptor excels in each capacity, the F-

[180] Thornborough, *Iron Hand*, 248-249. The F-4 was a two-seater, with the WSO as a SAM radar expert (Ibid).
[181] Schnabel, *Can You Create the Universal Pilot for the Universal Aircraft*, 8-10.
[182] Ibid., 10.
[183] Ibid.
[184] The fighter pilot axiom, "speed is life," indicates the importance of airspeed in every mission set. Typical combat speeds are between 0.8 and 1.2 Mach. Speed can be limited to .95Mach until off target with no external bombs remaining (due to bomb speed limits)—these speed limits are not restrictive for 5th Gen aircraft with no external stores. Therefore, as long as the top speed is reasonable, acceleration is a more important factor. Current fighters maintain a clean (no external stores) thrust to weight ratio of greater than 1:1; the F-105 and F-4 were 0.75:1 and 0.87:1 respectively (Hannah, *Striving for Air Superiority*, 44). While this ratio is not indicative of maneuverability, it can be a good indicator of available thrust and acceleration.
[185] Bubble canopies are indicative of good visibility; reference the P-51, F-86, F-15, F-16, and F-22 (*not the F-35*). A high ceiling is another indicator of superior climb and thrust capability. The internal cannon references the acknowledgement that dogfighting is a potential, as well as air-to-ground strafing during air-to-ground missions.

35 appears inadequate in multiple areas. The F-35's two to four internal AMRAAMs are not sufficient in an environment where Electronic Attack (EA) and smart adversaries, which further degrade missile P_k, are prevalent.[186] Additionally, official reports document the F-35s poor visibility, which is vital to most combat operations, especially air combat maneuvering.

> ...the ejection seat headrest and canopy bow were identified as causal factors…Aft visibility could turn out to be a significant problem for all F-35 pilots in the future, especially in more tactical phases...It remains to be seen whether or not...the visibility issues will rise to the level of safety issues...Unlike legacy aircraft such as the F-15, F-16, and F/A-18, enhanced cockpit visibility was not designed into the F-35...it is partially a result of designing a common pilot escape system for all three variants to the requirements of the short-take-off and vertical landing environment.[187]

These failures in air superiority design are only a few reasons the F-35 is extremely dependent on the F-22 in a high threat environment.[188]

History reveals that multi-role fighters procured without air superiority at the forefront of their design are less combat effective, and less survivable, than an air-to-air design that evolves into a multi-role fighter. It is possible that the F-35's "unprecedented capabilities" will permit a similar progression in capability that the SEAD mission experienced moving from the F-4G to the F-16CJ. Regardless, the F-35 will no doubt experience the same Viper "mission creep—too many capabilities to train to in their entirety."[189] Bred as a multi-role fighter to take over all the

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[186] The F-35 carries four internal AIM-120s in a stealthy air-to-air loadout; however, it is limited to two AIM-120s on stealthy multi-role missions. As previously stated from Lt Col Patrick Higby's paper, the Desert Storm BVR missile P_k was 18 percent, and the total missile P_k was 27.3 percent (these numbers assume no EA). In laymen's terms, if the P_k of a missile is 25 percent, one would need to fire four missiles in order to shoot down one adversary aircraft. When EA enters the equation, the number of missiles required to shoot down one adversary increases (P_k decreases). Furthermore, the F-35 cannot currently carry internal AIM-9s, a limitation in a WVR engagement. While the F-35 does have an internal 25mm cannon, it only carries 182 rounds, fired at 3000 RPM. This quantitative limitation only provides 3.64 seconds of fire, which amounts to 50 rounds per second—a limitation in air-to-air and air-to-ground combat operations.

[187] Michael J. Gilmore, *F-35A Readiness for Training Operational Utility Evaluation,* (February 2013), 17-18, http://pogoarchives.org/straus/ote-info-memo-20130215.pdf.

[188] Mehta, *Air Combat Command's Challenge.*

[189] Schnabel, *Can You Create the Universal Pilot for the Universal Aircraft*, 20. In order to deploy in support of OIF/OEF, F-16 SEAD squadrons increased CAS training and reduced SEAD training, to become combat effective. Ultimately, units become unqualified to perform certain combat missions in order to focus on others. (Ibid., 13-14).

mission sets of the F-16, F-15E, and A-10, the F-35 could acquire the same stigma as the French Bombardment, Combat, and Reconnaissance (BCR) aircraft.[190] "Controversies over costs and mission precluded midcourse corrections in the BCR program...they could not reverse course and admit that the theory of a multipurpose battle plane was technologically bankrupt."[191] Modern technological advances make the idea of *designing* a fighter-bomber more palatable; only time and the test of combat will reveal its success or failure. Failures in fighter acquisition result in combat ineffective aircraft, wasted taxpayer dollars, and an unnecessary combat risk for military pilots. As the DoD looks to future fighter aircraft procurement, it must design aircraft that are effective in all aspects of air combat to maintain a fighter strength capable of defeating enemy threats. However, weapon systems procurement programs that ignore historical lessons learned risk upsetting the balance between capability, technology, and versatility.

[190] The BCR was designed to do every existing mission.
[191] Robin Higham and Stephen J. Harris, eds, *Why Air Forces Fail: The Anatomy of Deafeat*, (Kentucky: The University Press of Kentucky, 2006), 55.

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