Flying Knights or Flying Scientists?
A Cognitive History of the US Air Force Fighter Pilot in Air-to-Air Combat, 1950-1980

by

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Submitted to the Engineering Systems Division in partial fulfillment of the requirements for the degree of

Doctor of Philosophy in Engineering Systems: Technology, Management, and Policy

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Abstract

US Air Force fighter aircraft underwent a remarkable transformation in the period from 1950 to 1980. Whereas the lone fighter pilots of earlier fame relied on the power of their eyesight, the finesse of their piloting skills, and a steady squeeze of the trigger to achieve victory, later pilots vanquished their foe by focusing on a four-inch-square cockpit display, manipulating electromagnetic waves, and launching rocket-propelled missiles from miles away. Two popular historical narratives dominate this period in fighter aviation: one of "great machines," which focuses on the technologies; the other of "great pilots," which focuses on the oft-heroic aviators. The former conjures notions of technological determinism; the latter, a timeless "myth of the fighter pilot." Regrettably, the two distinct approaches obscure the important human-machine interactions that linked the pilots with their fire control technologies.

This study presents an alternative perspective of fighter aviation, viewing it instead as an inseparable system of humans *and* machines working together. I develop a *cognitive history* of the air-to-air fighter pilot, analyzing three sequential experiences: the F-86E Sabre during the Korean War, the F-4C Phantom II during the Vietnam War, and the F-15A Eagle during a pair of air combat evaluations conducted in 1977. In each case, new fire control systems were introduced to simplify weapons employment and thereby free the pilot to focus attention on other tasks deemed more vital, such as flying itself. The pilots, however, soon realized that within air combat, their traditional *flying* skills were becoming less critical to their success and survival; in contrast, the skills required to operate their new fire control systems were growing in significance and complexity. With the pilots uniquely vested in sustaining the "fighter pilot myth," tension and conflict ensued, both within individual fighter cockpits and in the social relationships that extended between fighter cockpits.

This study offers fresh insight into issues of technological change that confront today's military aviators, especially regarding remotely piloted aircraft. More generally, this study addresses the tensions that often arise when increasing automation alters or displaces the tasks that have historically defined an individual's profession.

Thesis Supervisor: David A. Mindell
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Acknowledgments

Nearly six years ago on April 24, 2008, I flew my "fini flight" in an F-15C Eagle at Nellis Air Force Base (AFB), Nevada. The Air Force had decided then that I needed a second master's degree and it was sending me to Wright-Patterson AFB, Ohio, for a year-long program. I fully expected to be back flying the "World's Greatest Air Superiority Fighter" shortly thereafter. As such, I took no pains to make my last sortie a particularly memorable one. It was a simple one-v-one mission against a friend who was preparing to attend the USAF Weapons School in a few months. As luck would have it, his jet had a minor malfunction while we were airborne and we didn't even get to dogfight. Had I known then that it would be my last opportunity to experience the thrill of the flying a fighter, I would have devoted a little extra time and energy to savoring the experience.

One year at Wright-Patterson sitting in a classroom led to another year spent in another classroom at Maxwell AFB in Alabama. While I was still looking forward to climbing back into the Eagle, it was there at the Air Force's School of Advanced Air and Space Studies (SAASS), while reading big books and thinking deep thoughts in daily seminar, that I began contemplating a different career path. Encouraged by the faculty at SAASS, especially Stephen Wright, Tom Hughes, Steve Chiabotti, and Colonel Tim Schultz, I left Maxwell determined to bushwhack a path through the Air Force bureaucracy that would allow me to continue my studies. But a mid-grade major can't do much on his own at the Pentagon except fetch coffee, so I was fortunate to have two outstanding supervisors that not only challenged me to remain engaged intellectually, but also helped clear the path for me: Colonel David Fahrenkrug and Tom Ehrhard. At the other end, I encountered a remarkable fellow former Eagle pilot and friend who, in the midst of his own frantic studies and dissertation writing, helped facilitate my very tardy admissions application to MIT. I'm confident that without Colonel Ray "Krypto" O'Mara's assistance, I would not have had the opportunity to pace the Infinite Corridor in thought these last three years. For everyone that helped me get to MIT and their continued support while here, I offer my sincere thanks.

Turns out, it's been both blessing and curse. It can be an incredibly daunting experience sitting down with a keyboard and monitor each day, every day, trying desperately to churn out a dissertation on an accelerated Air Force timeline. Fortunately, I had a wonderful cadre of people helping me along the way: colleagues like Joy Rankin, John Tylko, Stephen Zoepf, J.C. Ryan, Josephine Wolff, Morgan Dwyer, Jonathon Krones, John Helferich, Xin Zhang, and Bill "Dollar" Young; professors like Roe Smith; friends like Reid Rasmussen, William "Small" Fry, Meg Martin; the Engineering Systems Division staff, especially Beth Milnes; the helpful staff at the Air Force Archives at Maxwell AFB, including Sylvester Jackson, Maranda Gilmore, and Leeander Morris; Brett Stolle at the Air Force Museum and Ray Ortensie at the Air Force Materiel Command Historical Office at Wright-Patterson; and Jerry White, the Air Force Historian at Nellis. And then there were those individuals that provided the essential first-hand accounts and experiences that were vital to my research: General Larry Welch (Ret.), General Jeff Cliver (Ret.), Dick Anderegg, Tom Sokol, Jere Wallace, Bill Sparks, and "Shad" Dvorchak. All air combat veterans, they graciously spent numerous hours of their time answering a "young punk's" repeated and sometimes naïve queries.

Throughout the entire process, my dissertation committee, and especially my advisor, David Mindell, exhibited faith in my progress when I thought I was simply spinning my wheels. On more than one occasion, their kind and encouraging words helped walk me back from the figurative ledge. I remember listening to Sheila Widnall speak at the Air Force Academy when she was Secretary of the Air Force and I was a lowly cadet; to have had the opportunity to work with an aerospace pioneer like her over the past three years has been an extraordinary privilege. Owen Coté provided the original inspiration for this dissertation project when we were spitballing potential topics and he asked if I knew anything about AIMVAL-ACEVAL. "Not much," I think I responded, "but that might be interesting." Owen was my go-to person when I needed help working through an idea. But it was David Mindell who helped me transform the topic into a full dissertation. In the process, I learned more than just a history of fighter aviation, but a new way to appreciate what I had always taken for granted when I was sitting in a cockpit. I look forward to applying the new perspective when I rejoin Mother Blue (Air Force) this summer.

Finally, the only person that can probably appreciate my attempt at humor when I say that this experience has also been a "curse" is my wife. She endured my near-constant fretting this past year, my anxiety attacks in the middle of the night, my stumbling around the house mumbling to myself as I tried to work through an idea, and she did it while working full-time and raising our three young children, a son and twin daughters. It wasn't always easy, but somehow we managed. Granted, we had some assistance from her mom in particular, as well as my parents and her sister, but I would be remiss if I thought for one second I could have done this without my wife's support. And to our children, yes, I'm just about done with my homework. Let's go out and play.

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Acronyms and Abbreviations

AAA ..... Anti-Aircraft Artillery
AB ..... Air Base (or Afterburner)
ACEVAL ..... Air Combat Evaluation
ACM ..... Air Combat Maneuvers
ACMI ..... Air Combat Maneuvering Instrumentation
ACS ..... Armament Control System
ACT ..... Air Combat Tactics
ADC ..... Air Defense Command
AFB ..... Air Force Base
AFHRA ..... Air Force Historical Research Agency
AGL ..... Above Ground Level
AI ..... Airborne Interceptor / Airborne Interception
AIM ..... Air Intercept Missile
AIMVAL ..... Air Intercept Missile Evaluation
AMCS ..... Airborne Missile Control System
AMRAAM ..... Advanced Medium Range Air-to-Air Missile
AOA ..... Angle of Attack
ASE ..... Allowable Steering Error
ATA ..... Antenna Train Angle
ATC ..... Air Training Command
ATS ..... Air Tactical School
AW ..... Automatic Weapons
AWACS ..... Airborne Warning and Control System
CAP ..... Combat Air Patrol
CAS ..... Control Augmentation System
CC ..... Central Computer
CRT ..... Cathode Ray Tube
CSAF ..... Chief of Staff of the Air Force
CW ..... Continuous Wave
DARPA ..... Defense Advanced Research Projects Agency
DDR&E ..... Director of Defense Research and Engineering
DTIC ..... Defense Technical Information Center
DWM ..... Distinguished Warfare Medal
ECM ..... Electronic Countermeasures
EID ..... Electronic Identification
ELINT ..... Electronic Intelligence
E-M ..... Energy-Maneuverability

EOIATS ..... Electro-Optical Identification and Tracking Set
FEAF ..... Far East Air Forces
FIG ..... Fighter-Interceptor Group
FIW ..... Fighter-Interceptor Wing
GAR ..... Guided Air Rocket
GCI ..... Ground Controlled Intercept
GIB ..... Guy-in-Back
GPS ..... Global Positioning System
HOTAS ..... Hands On Throttle and Stick
HUD ..... Head's Up Display
INS ..... Inertial Navigation System
IR ..... Infrared
JTF ..... Joint Test Force
LCG ..... Lead-Computing Gunsight
mil ..... Milliradian
MIT ..... Massachusetts Institute of Technology
Mk ..... Mark
MRM ..... Medium Range Missile
MSFRIC ..... Muir S. Fairchild Research Information Center
NARA ..... National Archives and Records Administration
NKAF ..... North Korean Air Force
NMUSAF ..... National Museum of the US Air Force
NVN ..... North Vietnam
NVAF ..... North Vietnamese Air Force
PACAF ..... Pacific Air Forces
PD ..... Pulse Doppler
POW ..... Prisoner of War
PRF ..... Pulse Repetition Frequency
RHAW ..... Radar Homing and Warning
RIO ..... Radar Intercept Officer
ROE ..... Rules of Engagement
RP ..... Route Pack
RPA ..... Remotely Piloted Aircraft
RTAFB ..... Royal Thai Air Force Base
RWR ..... Radar Warning Receiver
SAC ..... Strategic Air Command
SAGE ..... Semi-Automatic Ground Environment
SAM ..... Surface-to-Air Missile
SARH ..... Semi-Active Radar Homing
SEA ..... Southeast Asia
SOR ..... Specific Operational Requirement

SRAAM ..... Short Range Air-to-Air Missile
SRM ..... Short Range Missile
SVN ..... South Vietnam
TAC ..... Tactical Air Command
TCA ..... Track Crossing Angle
TD ..... Target Designator
TDC ..... Target Designator Control
TFS ..... Tactical Fighter Squadron
TFW ..... Tactical Fighter Wing
TFX ..... Tactical Fighter Experimental
TISEO ..... Target Identification System, Electro-optical
TVSU ..... Television Sight System
TWS ..... Track-While-Scan
UAV ..... Unmanned Aerial Vehicle
UHF ..... Ultra-High Frequency
UN ..... United Nations
US ..... United States
USAF ..... United States Air Force
USAFE ..... United States Air Forces in Europe
USN ..... United States Navy
Vc ..... Closing Velocity
VHF ..... Very-High Frequency
VID ..... Visual Identification
VSD ..... Vertical Situation Display
WRCS ..... Weapons Release Computer System
WSO ..... Weapons System Operator

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Chapter 1

Introduction:
Flying Knights or Flying Scientists?

The duty of the fighter pilot is to patrol his area of the sky and shoot down any enemy fighters in that area. Anything else is rubbish.

—Manfred von Richthofen, *circa* 1918

The poor souls that inhabited the muck and filth-filled subterranean world of trench warfare craned their necks skyward and gazed awestruck at the battle unfolding a few thousand feet above them. As the planes traced tight circles among the clouds, diving low and zooming high, the action for those on the ground must have been reminiscent of a closely choreographed ballet. But a sudden "snap," the sight of a plane crumpling, and the sound of it striking the earth with an ignoble "thud" reminded all that this was no barnstorming display manufactured simply for the troops' entertainment. Germany had two leading aviators the morning of June 18, 1916. Now one of them, Max Immelmann, was dead.[1] Shortly thereafter, the other, Oswald Boelcke, was given orders from the Kaiser that forbade him from ever flying again, thereby sparing the *Vaterland* the anguish of losing another of her heroic flyers. Boelcke was not happy. As he boarded a train bound for the Turkish Aegean coast, he lamented, "The worst of the whole business is that I am put out of action just at the very moment when … the enemy's flying activity is more intensive than ever before.... They are all pleased to have me sitting in a glass case."[2]

---

[1] (All notes appear in shortened form. For full details, see the appropriate entry in the bibliography). Wohl, *Passion for Wings*, 218–19; Morrow, *Great War in the Air*, 150; Hart, *Aces Falling*, 4. Immelmann's death, like many of the other great World War I aces, remains shrouded in mystery. He may have shot through his own propeller, the result of a faulty machine gun-interrupter gear, which in turn caused the engine to tear from its mounts and rip the plane apart, or he may have been shot down by a British airplane in the vicinity. Representative of a broader trend throughout the war, the German narrative favored the former; the British the latter.

[2] Werner, *Knight of Germany*, 204–209; Wohl, *Passion for Wings*, 218–20; Fritzsche, *Nation of Fliers*, 79.

The Kaiser's decree was short-lived, though. The exigencies of combat quickly overshadowed the notion that the successful fighter pilot could simply retire at such a perilous time. Boelcke was overjoyed. He raced back to Berlin and then on to his new squadron, stationed near the Somme. Accompanying Boelcke were two pilots he had discovered during his time touring the eastern front. Regrettably, Boelcke's new protégés would doom the great ace to relative obscurity. The first, Erwin Böhme, robbed Boelcke of his life, colliding with him during a battle on October 28, 1916, sending Germany's famed pilot and his aircraft plummeting earthward to be shattered below. The second pupil robbed Boelcke of his legacy; Manfred von Richthofen, not Boelcke, became history's iconic fighter pilot ace.[3]

Born to an aristocratic family, an excellent gymnast-athlete, and an avid hunter, Richthofen was the prototypical fighter pilot ace of the Great War. Educated, disciplined, fiercely competitive, and a good marksman to boot, Richthofen initially served as a cavalry officer. However, with trench warfare obviating the centuries-old need for horse-mounted soldiers, he became disenchanted and turned his sights to Germany's fledgling air service. His transfer request was honored, and the young Richthofen soon began flying combat missions near the eastern front. He already had several aerial encounters, but none resulting in a confirmed kill, when he caught Boelcke's attention.[4]

Richthofen prospered immensely from the personal, albeit brief, instruction Boelcke provided on his *Dicta* for air combat.[5] When Richthofen later assumed command of *Jasta* 11, he earned a reputation not only as a supremely talented aviator, but also as a respected leader. Following the "bloody April" 1917 aerial battles near Arras, in which Richthofen's pilots accounted for nearly a third of all aerial victories over the British Royal Flying Corps, Richthofen was promoted to *Rittmesiter* and given command of the new *Jagdgeschwader* 1. Richthofen's legendary "Flying Circus" was born, and its leader, now known for flying auspiciously painted red aircraft, achieved worldwide renown as the Red Baron.[6]

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[3] Wohl, *Passion for Wings*, 220–22; Fritzsche, *Nation of Fliers*, 80–82.

[4] Kilduff, *Richthofen*, 44–50; Wohl, *Passion for Wings*, 223–24.

[5] *Dicta Boelcke* was a set of seven precepts for air combat. They "became the standard reference for all other *Jasta* pilots, and their basic principles applied to a new generation of fighter pilots during World War Two, for whom they appeared in printed booklet form." Franks, "Introduction," 4–5.

[6] Wohl, *Passion for Wings*, 225–27; Fritzsche, *Nation of Fliers*, 82.

Richthofen was typically "dispassionate" in the reports he filed following his aerial victories. His account of his seventy-fifth victory, which occurred on April 2, 1918, shortly after he took command of the Flying Circus, was no different. It offers a valuable description of what air combat entailed during the later stages of the First World War:

> About 12:30pm I attacked a British R.E. [aircraft] at an altitude of 800 metres above the woods at Moreuil, [and] just below the clouds. As the adversary did not see me until very late, I managed to approach within 50 metres of him. I fired from ten metres' distance until it began to burn. When the flames shot out, I was only five metres away from him. I could see the pilot and observer twisting out of their aeroplane [seats] to escape the flames. The machine did not burn in the air, but gradually burned [on the way] down. It fell out of control to the ground, where it exploded and burned to ashes.[7]

After the mission, Richthofen was awarded the Order of the Red Eagle Third Class with Crown and Swords, an honor normally reserved for regimental commanders celebrating strategic victories. Richthofen, ever the "modest, open, sincere person" in the words of one fellow pilot, noted the irony: "[There was] never a strategic victory. Every air battle, no matter how big it is, always ends up in individual combats."[8]

Each nation during the Great War reveled in its heroic flying aces: America had Eddie Rickenbacker; France, Roland Garros and Georges Guynemer; Britain, Albert Ball. But among them all, only Richthofen transcended national borders. Before his death, Richthofen sent at least eighty Allied planes tumbling to the ground, along with a good number of their crews. Yet despite his hand in the deaths of many of their comrades, Allied pilots still routinely toasted the famed German flyer. One London journalist observed in 1918 when talking with a group of British aviators that, although all professed a strong desire to be the one who brought the Baron down, "there is not one who would not equally have shaken hands with [Richthofen] had he been brought down without being killed or who would not so have shaken hands if brought down by him."[9] When Richthofen was finally felled behind Allied lines on April 21, 1918, most likely not by another pilot but instead by a

---

[7] Kilduff, *Richthofen*, 193.

[8] Ibid., 194.

[9] Driggs, "Aces Among Aces," 574; Wohl, *Passion for Wings*, 250.

round fired from a machine gun on the ground, Allied troops conducted a solemn military funeral, complete with rifle salute, for their "gallant and worthy foe."[10]

The iconic Red Baron lives on today, battling Snoopy, jamming to the tunes of Led Zeppelin, and rolling out tasty frozen pizzas.[11] Richthofen, more so than any other pilot, came to symbolize the mythical flying ace, a chivalric and noble knight that rose like a phoenix from the morass of mechanistic warfare during the Great War to restore humanity's faith in itself. Unlike those countless muddied soldiers climbing out of trenches and racing to their deaths at the sound of a starter's gun, a pilot like Richthofen survived, and captured glory, through individual cunning and skill.[12] Widely popularized stories of aviators pausing in battle to acknowledge each other's flying acumen or dropping wreaths on the wreckage of a fallen foe similarly rekindled in the citizenry notions of long-lost battlefield gallantry and honor.[13] And in contrast to the chateau-bound, medal-encrusted, white haired generals that measured victory in yards of No Man's Land captured, the dashing youths clad in leather jackets and silk scarfs that took to the heavens had an irreducibly simple mission—find the enemy and force him from the sky. "Anything else is rubbish," Richthofen purportedly once remarked.[14] Even heads of state celebrated the aces as the "cavalry of the clouds.... They are the knighthood of the war, without fear and without reproach."[15]

---

[10] Kilduff, *Richthofen*, 199–205; Persico, *Eleventh Month, Eleventh Day, Eleventh Hour*, 218; Driggs, "Aces Among Aces," 574. The tribute was inscribed on a wreath placed on Richthofen's casket. A London correspondent noted that a few days before Richthofen's death, "one of the best of our airmen expressed the hope that he and von Richthofen might survive the war, so that they might compare notes."

[11] Singer, *Wired for War*, 363; Wohl, *Passion for Wings*, 250.

[12] On the mechanistic horrors of the Great War and its challenge to the notion that a nation's technological superiority was the "surest proof of their civilization's superiority," see Adas, *Machines as the Measure of Men*, chap. 6. On the flying ace as a restorative tonic for the Western psyche, see Wohl, *Passion for Wings*, chap. 7; Fritzsche, *Nation of Fliers*, chap. 2.

[13] Fritzsche, *Nation of Fliers*, 88. The discrepancy between the public image of gallantry and fairness and the sordid reality of sneaking up on lumbering reconnaissance planes, as Richthofen had done on his seventy-fifth victory, is a topic for Chapter 2. See also Hart, *Aces Falling*.

[14] Richthofen's "duty of the fighter pilot" is an oft-cited aviation expression. As with most popular historic quotes, several versions exist and no authoritative source can be found. The version cited in the epigraph and here is from English, *Slipping the Surly Bonds*, 89. For a sampling of other versions of the quote, see: Boyne and Handleman, *Brassey's Air Combat Reader*, 6; Middleton, *Air War-Vietnam*, 210; Hettena, *Feasting on the Spoils*, 26; Wilcox, *Scream of Eagles*, 185.

[15] Pisano et al., *Legend, Memory, and the Great War*, 29. Pisano et al. cited a wartime speech by David Lloyd George celebrating the aviators: "The heavens are their battlefield; they are the Cavalry of the clouds. High above the squalor and the mud, so high in the firmament that they are not visible from the earth, they fight out the eternal issues of right and wrong.... Every flight is a romance; every report is an epic. They are the knighthood of the war, without fear and without reproach. They recall the old legends of chivalry, not merely

Richthofen's iconic red triplane, the Fokker Dr.I, had long since vanished from the sky by the time of the Korean War nearly thirty-five years later, but the myth of the Flying Knight and his tactics remained. Patrolling MiG Alley, F-86 Sabre pilots of the fledgling US Air Force clamored at the chance to down an enemy MiG fighter. Earlier, Richthofen had implored his *Jasta* pilots to have "the courage to fly in close to the enemy before opening fire." It was a lesson adopted from Boelcke's *Dicta*, "the secret of aerial victory."[16] Now in Korea, flying jet-powered aircraft at velocities approaching the speed of sound, some of which were equipped with a new radar-ranged, lead-computing gunsight that promised longer-range firing opportunities, American Sabre pilots were instructed to do the same. Leaders of the 4th Fighter-Interceptor Group (FIG) implored their pilots, "'when in doubt, attack'—be a determined, aggressive killer—thats [*sic*] what you're flying a fighter for."[17] In another Sabre unit in Korea, the 51st FIG, pilots were told, "'Every man's a Tiger!' The aggressive spirit must always be foremost if the pilot and his organization are to enjoy a successful career in the fighter business."[18]

Like the majority of young Sabre pilots flying in MiG Alley, First Lieutenant Douglas Evans "sure wanted to become an ace" when he set sail from San Francisco destined for war.[19] He was the youngest son of the decorated Marine Colonel Francis T. Evans Sr., the fourth Marine Corps officer to complete aviation training and the first to perform a loop-to-loop in a seaplane. The day he turned eighteen, the younger Evans had raced off to enlist in the Army Air Forces the day he turned eighteen. But it was already 1943, and after his nineteen-month flight training program, the freshly winged Evans joined scores of other new pilots wilting in the Texas heat waiting for an invitation to the Big War that never came. He was discharged and went back to school. After stints flying for the Reserves and the Air

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the daring of their exploits, but by the nobility of their spirit, and amongst the multitudes of heroes, let us think of the chivalry of the air."

Charles Lindbergh too saw the parallels between the valiant aces of World War I and the medieval knights: "After the war started, I search newspapers for reports of aerial combats—articles written about Fonck, Mannock, Bishop, Richthofen, and Rickenbacker.... Attacking enemy fighters, bombers, and balloons in mortal combat, [they] represented chivalry and daring in my own day as did King Arthur's knights in childhood stories." Lindbergh, *Autobiography of Values*, 63.

[16] Hart, *Aces Falling*, 45. See also Kilduff, *Richthofen*, 238.

[17] *4th FIG Tactical Doctrine*, July 22, 1951, 2. The organizational hierarchy within the Air Force typically adheres to the following pattern (from top to bottom): HQ Air Force, Major Command (either functional or geographic), Numbered Air Force, Wing, Group, Squadron.

[18] *Resume of Our Tactics*, 16–17.

[19] Evans, *Sabre Jets Over Korea*, 217.

National Guard, and numerous letters to the Pentagon, Doug Evans managed to score a coveted F-86 assignment to Korea, arriving aboard the *General John Pope* in mid-1951. After spending a few months learning the intricacies of jet combat while flying as a wingman alongside a more experienced flight leader, Evans finally got the opportunity to lead others into combat.[20]

One afternoon in early November 1951, Evans was leading Green flight, a formation of four F-86 Sabres. He was accompanied by three other four-ship Sabre formations, Red, White, and Blue flights. All were collectively assigned the task of seeking out and destroying enemy MiG fighters that might try to disrupt the Allied aircraft hurtling bombs at the Chinese Communist troops below. Approaching the Yalu River border that divided North Korea from the Communist sanctuary in Manchuria, the radio in Evans's "Spartan" cockpit erupted with chatter. Another group of Sabres slightly ahead of Evans's group had spotted twelve MiGs rocketing across the river. Moments later, a member of White flight called out eight more MiGs that were trying to sneak around the right side of Evans's group. Evans in turn spied four more approaching from the front-left side. Then, the leader of Blue flight chimed in that there were six more MiGs approaching from the left. Evans later recalled, "Everybody went into a general dogfight, Sabres and MiGs churning around everywhere I looked.... It seemed like no matter who I started after, there were always others coming at me to keep my eyes from my gunsight—a very exasperating situation."[21]

Throughout the ensuing melee, Evans's wingman, Green 2, performed admirably, maintaining a steady formation position scarcely 200 feet alongside Evans.[22] The intent behind this "fighting wing" position was that with the wingman so near the flight lead, he could easily cover the flight lead's tail, which in turn would allow the leader to focus his full attention on spotting a MiG, maneuvering into position, and prosecuting a successful gun attack. "The flight and element leaders are the 'shooters,'" the 51st FIG's manual on air tactics decreed, "and the wingmen are the 'lookers.'"[23] The arrangement was slightly counterintuitive. Shooting down an enemy aircraft was in some ways an easier assignment than trying to fly alongside someone who was trying to score a kill against a wild and

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[20] "Here's a Fighting Man"; Evans, "I Fight the Red Jets"; Evans, *Sabre Jets Over Korea.*

[21] Evans, *Sabre Jets Over Korea*, 130–31; Evans, "I Fight the Red Jets."

[22] Evans, *Sabre Jets Over Korea*, 131; Evans, "I Fight the Red Jets," 90.

[23] *Resume of Our Tactics*, 12.

unpredictable target. Remembering his first missions in Korea, Evans remarked, "Flying as a wingman in a wild dogfight is the toughest combat job there is."[24]

At one point during the swirling dervish, Evans and his wingman ended up directly above a MiG, "close enough to make out the pilot through his canopy and notice that some of the red paint had peeled off the nose of his plane." But before Evans could descend into position on the MiG's tail, he noticed "two more swept-wing jobs coming right up our tails."[25] Evans bent his jet around to thwart the attack, but then he spied twelve distant specks, rapidly growing, on the horizon—more MiGs. After another series of high-G, heart-pounding maneuvers, Evans and his wingman ended up behind two of the MiGs in a steep, climbing right turn. Evans explained:

> In the first moments I closed slightly, concentrated on the [MiG] wingman, and began hammering away, but my blasted gunsight was out of whack … so I was forced to guess range and lead…. I hit him with two or three flashes out of four or five bursts, but we had gotten into such a steep spiral it was tough to maintain any steady aim…. I was steadily losing ground until it seemed like we were falling backwards. My controls were mushy from the low airspeed, so I checked our tails before a last squirt and rolled over and down—talk about frustrated, and those two MiGs, going right up like elevators, disappeared through the overcast [clouds].[26]

Despite missing out on the kill, Evans took pride in the fact that "this hunting is fair, and the game has an equal opportunity of blowing your head off if you flub your vigilance or goof a maneuver. These counter-moves of opposing planes trying to kill each other is the damndest game of chess: you hardly have time to realize how dangerous it is."[27]

Whereas Evans and Richthofen had roughly comparable air combat experiences despite being separated by almost thirty-five years of extraordinary aerospace research, when Air Force First Lieutenant David "Abby" Sveden Jr. launched from Incirlik Air Base (AB) in Turkey on the afternoon of January 19, 1991, he took to the skies armed with a vastly different conception of air combat. Granted, there were some similarities. For example, Sveden's task that afternoon was similar to that of the earlier fighter pilots, seek out and destroy enemy aircraft. And Sveden, like Evans before him, flew in a formation with other

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[24] Evans, *Sabre Jets Over Korea*, 105.

[25] Ibid., 131–32.

[26] Ibid., 133.

[27] Ibid., 163.

fighter aircraft. But rather than being tucked alongside his flight members as Evans's flightmates had been, Sveden was flying more than two miles away from them in a formation known as "tactical." The responsibilities were different, too. In this formation, each pilot shared responsibility for monitoring the formation's vulnerable six o'clock position while simultaneously scanning the sky ahead with the Eagle's powerful radar. If anyone, including a wingman, detected a target, they were expected to immediately initiate the electronic identification (EID) process, communicate the target's presence to other members of the formation using agreed-upon code words, and if appropriate, maneuver into position to launch a high-speed missile at the target.[28]

Sveden, a youngster on his first F-15 assignment who had only been in the Air Force for four years, was flying in the number four position in Rambo flight on the January 19 mission.[29] Along with the other four-ship of F-15s in Conan flight, Sveden was tasked with escorting more than sixty aircraft to attack targets near Kirkuk in northern Iraq. As the Eagles turned southward from their staging point in eastern Turkey and crossed over the Iraqi border, the F-15 pilots were alerted to the possible presence of two Iraqi fighter jets in the area. Radar controllers aboard an orbiting E-3 AWACS (Airborne Warning and Control System), a modified Boeing 707 with a large, rotating Frisbee-looking radar dish mounted on top of the fuselage, were broadcasting that they had intermittent contacts orbiting over an airfield near the target. The Eagles pushed south.[30]

At a distance of forty miles, several of the Eagle pilots observed a small green "brick," a synthetically generated radar target, appear about halfway up their four-inch by four-inch square radar scope, offset slightly toward the right side. The position of the radar target roughly corresponded to the last known position of the enemy fighters that AWACS had reported earlier. Sveden quickly commanded a radar lock and started the EID process. After a few moments, he knew the radar targets to be enemy fighters, and he reported that

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[28] Davies, *F-15C Eagle Units in Combat*, 57–59; Deur, "Wall of Eagles," iv.

[29] Deur, "Wall of Eagles," 19; Davies, *F-15C Eagle Units in Combat*, 57. The "Rambo" callsign was pirated from Sylvester Stallone's 1982 movie of the same name, in which the title character, John Rambo, singlehandedly lays waste to an entire small town. Another popular Eagle callsign had similar cinematic roots; the callsign "Conan" refers to Arnold Schwarzenegger's 1982 movie *Conan the Barbarian*. The two callsigns were (and still are) routinely used by F-15 flights at the USAF's Weapons School at Nellis AFB, Nevada. For the January 19, 1991, mission, the Eagle flight lead, a recent USAF Weapons School graduate, found the higher-headquarters assigned callsign for his formation—JJ—lacking, so he renamed his and the accompanying formation Rambo and Conan.

[30] Deur, "Wall of Eagles," 19–20; Davies, *F-15C Eagle Units in Combat*, 58.

fact to his flightmates using the radio. As the distance to the enemy targets collapsed to twenty miles, the F-15 pilots observed the single "brick" split into two, which indicated the presence of at least two aircraft. The Rambo flight lead, Captain Steve "Gunga" Dingee, directed the other F-15s in Conan flight to continue south with the strike package; Rambo, he declared, was turning west to intercept the enemy fighters.[31]

Dingee in Rambo 1 and Captain Dan "Spyro" Prather in Rambo 3 both locked on to the radar targets according to the prebriefed targeting plan: Dingee locked the target on the left; Prather, the one on the right. Two short radio calls later and the Eagle pilots were sure that they had targeted the two separate aircraft: Rambo 1's target was flying at 9,000 feet; Rambo 3's target was a couple-thousand feet lower at 7,000.[32] For Sveden, a quick glance inside the cockpit at his radar display confirmed that he was locked to the same 9,000-foot altitude target as Rambo 1. That was a good thing, since it meant that he and his element leader, Prather in Rambo 3, were "sorted" to different targets.[33] From fifteen miles away, the Eagles already knew where their foes were, how many there were, what altitude they were flying at, what type of aircraft they were flying, and which Eagle was going to shoot which target when the time came.

The turn to the west toward the Iraqi fighters had pushed Sveden and Prather out in front of Rambo 1 and 2. At a distance of ten miles to the enemy aircraft, the designated missile-firing range, Sveden pressed the red pickle button on his control stick and one of his four, twelve-foot-long, radar-guided AIM-7 Sparrow missiles rocketed off toward the target. Seconds later, Prather launched a missile against his target. Sveden quickly glanced back inside his cockpit and checked his 360-degree Radar Warning Receiver (RWR)—no enemy was targeting him. Sveden and Prather, still about 10,000 feet above their unsuspecting prey, pushed forward on their control sticks and started to descend. They peered through the small Target Designator (TD) box in their Head's Up Display (HUD) that indicated where

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[31] Deur, "Wall of Eagles," 19–20; Davies, *F-15C Eagle Units in Combat*, 58.

[32] Davies, *F-15C Eagle Units in Combat*, 58; Deur, "Wall of Eagles," 20. Sveden recalled the radio exchange. "In my view, No. 3 then demonstrated the best comm and execution of any of the F-15 kills—as cool as you could possibly be, he called, "'Rambo 3" has a side-side breakout on the nose for 20.' No 1 came back and said, "'Rambo 1," same.' Then No. 3 responded, "'Rambo 3" sorted side at 7000,' followed by "'Rambo 1" same, 9000.'" Prather emphasized that the radar procedures were something "we do every day in training."

[33] Davies, *F-15C Eagle Units in Combat*, 58–59; Deur, "Wall of Eagles," 19–20. As Prather later explained, "Wingmen are supposed to look for other contacts, and then their goal in life is to lock someone different than their flight lead, so 'Abby' locked a different guy than I had."

they should look to find their targets. At about eight-miles range, a small black dot appeared in the center of each pilot's TD box.[34] Just to be sure, Sveden and Prather fired a second missile at each target from a distance of about four miles. Prather recalled:

> About this time, the first missile hit the first guy. They were [both hit] within a couple of seconds of each other, but I think Abby's missile hit his guy first.... It made a pretty big fireball, and you could see this fireball descending rapidly from 8,000 or 10,000 feet down toward the Tigris River. Almost instantly, the second [target] was hit, making a big round blossoming orange-black fireball. I couldn't really see any debris falling from it; it just engulfed the whole thing. Those [hits] were from our first missiles. Our second missiles weren't even required, but I remember seeing them guide through the fireballs and exploding when they got near the debris.[35]

Sveden's and Prather's experience of launching a missile at an enemy target before ever visually seeing it was similar to about half of the USAF Eagle's thirty-four kills in Desert Storm.[36] One Eagle pilot who eventually racked up three kills during the war, Captain Rhory "Hoser" Draeger, described his victories: "For me, at least up to that point, it was the highlight of my career. After working all those years for that time and that place, it all came together. It worked out quite nicely.... It was something special."[37]

But for Draeger, Sveden, Prather, and the other Eagle pilots, it was also something vastly different than Evans's experience of air combat in an F-86 Sabre. Evans, as Richthofen had before him, needed to rely on keen eyesight to gain the advantage that accrued to the pilot who first sighted his adversary; Sveden and his fellow Eagle drivers used

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[34] The turn to the west toward the Iraqi fighters had also placed Rambo flight looking into the setting sun, a clear violation of *Dicta Boelcke's* second rule: "Try to place yourself between the sun and the enemy. This puts the glare of the sun in the enemy's eyes and makes it difficult to see you and impossible for him to shoot with any accuracy." Boelcke's *Dicta* is included in Franks, "Introduction," 5.

[35] Deur, "Wall of Eagles," 22.

[36] Toward the end of the war, Eagle pilots started racking up victories against Iraqi jets that were fleeing to Iran; many of these kills were achieved at close-range from a stern position. But of all the Eagle engagements in Desert Storm, only two even resembled the close-range, swirling dogfights of prior aerial battles. On January 19, Captain "Cherry" Pitts and Captain "Kluso" Tollini tangled with a pair of MiG-25 Foxbats. At one point during the confusing battle, Tollini was chasing an aircraft that had its afterburners lit. Just to make sure he was behind an enemy aircraft and not a friendly Eagle, Tollini queried his flight to see if anybody was using afterburner.

That same day, Captain "Mole" Underhill and Captain "Rico" Rodriguez encountered two Iraqi MiG-29s. Underhill destroyed the first MiG at range, but following some precautionary defensive maneuvers, the pair of Eagles found themselves visually engaged with the second MiG. The Eagles started a climbing turn to engage the lone MiG. The MiG started a descending turn to engage the Eagles. A few moments later, the MiG crashed into the desert floor below. Ibid., 16–19.

[37] Ibid., 15.

the power of electromagnetic energy emanating from both the distant, orbiting AWACS and the powerful radars installed in their own aircraft to detect their foes from more than forty-miles away. For Richthofen and Evans, victory demanded the courage to close within a quarter-mile before hammering away with their aircraft's machine guns, and the stick-and-rudder skills to gain and maintain that offensive position even if the enemy started to react defensively. Sveden only needed to turn his aircraft about sixty-degrees to the right, use the middle finger of his left hand to lock the unsuspecting Iraqi aircraft, glance at his RWR to determine if he was at risk of being shot down, and then push the pickle button with his right thumb to send a nearly 400-pound missile on its way to obliterate his adversary. How could Evans and Sveden both consider themselves "fighter pilots"?

The Question

Long before Desert Storm, while American Sabres and Soviet MiGs were still tangling with each other in the skies over Korea, the editors at *Life* magazine in February 1952 published an eight-page, illustrated spread depicting the remarkable transformation in "US military aviation from World War I to the present." Looking toward the future, the article claimed that fighters may soon reach "speeds of more than 1,000 mph" and "rockets may soon replace machine guns." Moreover, it predicted that the new armament would be aimed automatically by an "electronic 'brain'" carried aloft in the small fighter. Surveying these amazing technological advances looming on the horizon, the *Life* editors declared, "Fighters are rapidly becoming *planes flown by men more like scientists than pilots.*"[38]

This dissertation investigates the transformation of aerial warfare in the period from 1950 to 1980, from the close-fought, swirling melees of Evans's time in Korea to the immediate precursor to Sveden's video-game-like war in Desert Storm. I address two questions: How did evolving weapons technologies alter the traditional tasks and the professional identity of Air Force fighter pilots, and how did the fighter pilots respond?[39] In

[38] "From Struts to Jets," 62–63. Emphasis added.

[39] Some pilots contend that the term "fighter pilot" refers to "an attitude." Hence, "not all of those who fly a fighter aircraft are fighter pilots, and indeed there are multitudes flying cargo, bomber, rotary-wing and utility aircraft who are unconditionally qualified and deserving of the title." Handley, *Nickel On The Grass*, xv. While not necessarily disagreeing with Handley's sentiment, for the purposes of this dissertation, I use the term *fighter pilot* in the stricter sense, simply referring to those pilots who flew aircraft that included as a primary mission giving battle to other aircraft in the air.

other words, did the pilots remain flying knights in the image of the Red Baron or did they become the flying scientists that *Life* predicted? Innocuous as these two questions may seem, they compel us to investigate the multi-faceted relationship that exists between humans and their machines, especially when that relationship is influenced by an iconic and cherished myth. Moreover, addressing these questions with respect to this time period in fighter aviation development allows us to study the evolution of human-machine interactions during a period of increasing automation and dramatic technological change, the lessons of which are not limited to discussions of fighter aviation from yesteryear.

Perspectives on Fighter Aviation

There is an obvious human story within fighter aviation, of dashing and brave flyers taking to the sky to hunt down enemy aircraft. There is an equally compelling story of impressive technological achievements that powered aircraft and their accompanying weapons ever higher and faster. *Life* in 1952 hinted at the fascinating intersection of the two, but too often aviation histories have only examined one or the other.[40]

Many texts focus attention on the cultural aspects of being a fighter pilot. These tales, often in the form of pilot memoirs or biographies, typically reify the fighter pilot as an iconic and heroic figure. The stories are remarkably consistent. Exposed to aviation (but not necessarily military aviation) at an early age, a boy becomes enamored with the dream of flying fighters.[41] He enters flight training and finds the competition both challenging and rewarding. Sometime during his flying career, he has a harrowing experience in which his

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With regards to the term *weapons technologies*, I use it to refer generically to the fire control systems—the combination of aiming and targeting systems and the projectiles they used, be they bullets or guided missiles—that were installed in the fighter aircraft.

The term *professional identity* refers to "a social label [rooted in a professional community] to which others orient in interaction and by which actors announce themselves to the world." Barley, "Careers, Identities, and Institutions: The Legacy of the Chicago School of Sociology"; Hotho, "Professional Identity - Product of Structure, Product of Choice." See also Abbott, *System of Professions*, 8–9, 19–20. Abbott argued that professions are not defined by their "organizational structure," but rather by the "differentiation in types of work" they perform: "The central phenomenon of professional life is thus the link between a profession and its work, a link I shall call jurisdiction." Thus, when there are changes in the content and "control of work," such as in this case of changing technologies in fighter aviation, conflicts can erupt over "jurisdiction" and the identity of the professional tending to the task. On the topic of military professionalization, see: Huntington, *Soldier and the State*; Janowitz, *Professional Soldier*.

[40] Other aviation histories focus on the efficacy of using aircraft in war. See for example: Biddle, *Rhetoric and Reality*; Pape, *Bombing to Win*; Clodfelter, *Limits of Air Power*.

[41] Because women pilots were barred from flying USAF fighter aircraft until 1993, references to the fighter pilots in this dissertation are exclusively masculine.

aircraft fails him. Through quick thinking, skill, and some luck, he survives, learning from his near-accident and becoming a better pilot because of it. He eventually looks back on his flying days and his fellow pilots with pride and admiration. Within these standard "great pilot" narratives, the individual commands center stage, and often the only pages devoted to detailing the pilot's interactions with his aircraft are those that describe how the heroic pilot compensated for a sudden mechanical breakdown or technological failing. The usual lesson is that technologies rarely work as advertised; consequently, a pilot's survival depends on his possessing the "right stuff."[42]

This dominant narrative often conjures notions of a mythical, timeless fighter pilot. Traits and skills that were valuable for the Red Baron, such as good eyesight, excellent hand-eye coordination, and a daredevil-like aggressiveness that bordered on recklessness, are perceived as still being the critical components of being a fighter pilot today. For example, aviation historian John Sherwood attributed the demise of the raucous "flight suit attitude" of Korean fighter pilots not to any corresponding changes in technology, but to the fact that today "there are plenty of other pilots who want to fly F-15s and are willing to behave themselves for the privilege."[43] Similarly, DARPA (Defense Advanced Research Projects Agency) commissioned a study in the mid-1970s to identify "those critical characteristics and skills which … characterize the combat effective pilot" in the hope of identifying and cultivating promising fighter pilots earlier in their careers.[44] At the same time, the Air Force commissioned its own Corona Ace program to interview former ace pilots so that it could compile its own "historical perspective on air-to-air combat, study fighter tactics and training, and develop a profile for the selection of future fighter pilots."[45] However, both studies tended to overlook the role of new technologies in evolving fighter pilot traits and skillsets. In particular, the DARPA study's final report made little distinction between a successful fighter pilot from World War II and one from Vietnam, thereby obscuring any

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[42] See, for example: Yeager, *Yeager*; Mahurin, *Honest John*; Trest, *Once a Fighter Pilot*; Blesse, *Check Six*; Handley, *Nickel On The Grass*; McCarthy, *Phantom Reflections*; Olds, *Fighter Pilot*. In addition to the above memoirs, fighter pilots' motivations, characteristics, and their seeming uncanny ability to overcome technological and bureaucratic impediments are also covered in: Wolfe, *Right Stuff*; Andrews, "To Fly and Fight"; Michel, "Revolt of the Majors."

[43] Sherwood, *Officers in Flight Suits*, 164.

[44] Youngling et al., *Feasibility Study to Predict Combat Effectiveness*, 1–1.

[45] The purpose of the Corona Ace interviews is taken from the preface of Olds, Corona Ace Oral History Interview.

potential effects of changing technology on the fighter pilot's necessary skillset. Collectively, these assessments and pronunciations simply propagated the myth of the timeless fighter pilot.

Other texts focus on the technological artifacts of military aviation, particularly the aircraft, radars, and guided missiles that constituted the new weapons systems of the 1950s, '60s, and '70s. Here, a consistent "great machine" narrative dominates, in which amazing technological gadgetry provided a welcomed advantage for the pilot. If, by chance, the equipment proved deficient, then the engineers returned to their drafting tables and laboratories and worked steadfastly to refine their promising technologies. One of the predominant narratives in this genre suggests that following the Air Force's disastrous experience in Vietnam, the service rededicated itself to getting "back on the right track to field superior technology and a world-beating force"; the success of Desert Storm naturally followed.[46] At times, these overly deterministic narratives conjure notions of war-winning technologies that possess "a seemingly magical power of historical agency." Furthermore, the "great machine" narrative often obscures the fact that human pilots still needed to learn how to operate the new technology, unless of course the service had a supply of "great pilots" on-hand that could effortlessly and naturally fly the faster and more maneuverable aircraft rolling off assembly lines.[47] Representative of this interpretation, one 1973 cartoon in *Air Force Magazine* depicted the F-4 as the most recent incarnation in a steady stream of airpower advancements, "a super bird flown by super jocks!" (figure 1.1).[48]

It is important to note that not all "great machine" narratives succumb to the fallacy of technological determinism, in which technologies appear to possess a "trajectory" all their own, ceaselessly marching along toward inevitable improvement while compelling

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[46] Werrell, *Chasing the Silver Bullet*, 7. The vast majority of popular aviation texts that focus on specific aircraft fall into this category of literature; see, for example: Thompson and Dildy, *F-86 Sabre vs MiG-15*; Werrell, *Sabres Over MIG Alley*; Thornborough and Davies, *Phantom Story*; Thornborough, *USAF Phantoms*; Davies, *USAF McDonnell Douglas F-4 Phantom II*; Davies, *USAF F-4 Phantom II MiG Killers, 1965-68*; Davies, *F-15C Eagle Units in Combat*.

[47] Marx, "Technology," 576–77. Invoking Marx's metaphor, "estimating the 'impact' of [a] technology on our society is a bit like estimating the impact of the bone structure on the human body."

[48] Stevens, "There I Was." The military's alpha-numeric system of designating aircraft contributes to this deterministic perspective, as more sophisticated aircraft that possess higher-numbers, e.g. the F-15, replace inferior aircraft with lesser-numbers, e.g. the F-4.

humankind to conform to their dictates.[49] For example, Ron Westrum's research on the Sidewinder missile and the Navy's China Lake weapons lab offers a superb look at the human motivations and power relationships that collectively shaped the design, development, and adoption of one of history's most successful air-to-air missiles.[50] Similarly, Glenn Bugos's examination of the McDonnell F-4 Phantom II revealed how the multitude of parts that went into the Phantom were themselves an amalgamation of various engineering teams' practices and procedures.[51] However, in their enthusiasm to unpack the black boxes of particular aviation technologies, many of these historians have overlooked a critical component of the human-machine relationship—that of the individual pilot. It as if

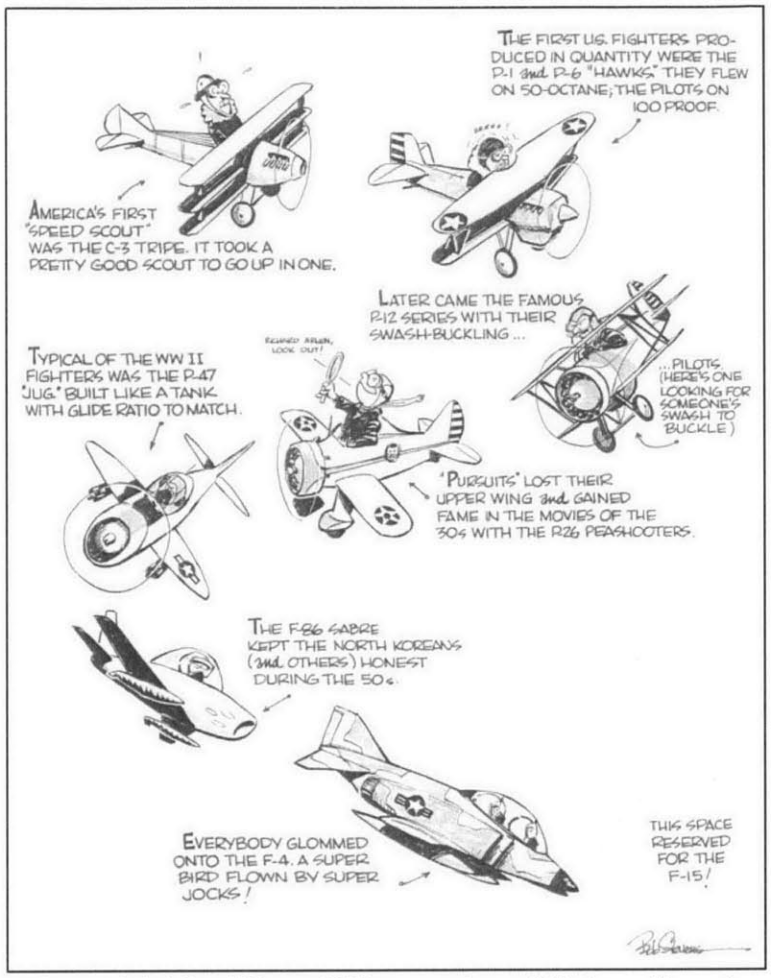

Figure 1.1. The "Natural" Progression of Fighter Aircraft.
(Source: Stevens, "There I Was," *Air Force*, May 1973)

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[49] On the historiography of technology, see: Kranzberg, "The Newest History: Science and Technology"; Usselman, "From Sputnik to SCOT: The Historiography of American Technology." On the competing perspectives of technological determinism and socially constructed technologies, see: Smith and Marx, *Does Technology Drive History?*; Bijker, Hughes, and Pinch, *Social Construction of Technological Systems*. The classic example of "prying open the black box of technology" and "technological trajectories" is the study of nuclear missile guidance in MacKenzie, *Inventing Accuracy*. In addition to MacKenzie's work, Thomas Hughes's writings on large technological systems are of particular interest to the present discussion, including: Hughes, *Networks of Power*; Hughes, *American Genesis*; Hughes, *Rescuing Prometheus*; Hughes and Hughes, *Systems, Experts, and Computers*.

[50] Westrum, *Sidewinder*.

[51] Bugos, *Engineering the F-4*.

by opening an artifact's black box, it became necessary to seal the operators of that technology in a black box all their own.

The Method: A Human-*and*-Machine Perspective

It is possible to study the intersection of the human and the machine using a socio-technical perspective that does not unduly privilege one at the expense of the other. But to do so requires that we abandon the strictly "great human" or "great machine" narrative. Constructing a cognitive history of the operator offers one approach. By analyzing how the human operator is situated in and interacts with his or her environment, including the machinery therein, we can begin to appreciate the important interactions that characterize the performance of the larger system.[52] Three primary authors provide the theoretical bedrock for the approach that I take in this dissertation: Edwin Hutchins, Thomas Sheridan, and Richard Sennett.

Hutchins crafted his *Cognition in the Wild* as a challenge to the predominant understanding of cognitive science. Railing against the decades-old practice of studying the human mind as an individual computer performing symbols recognition and manipulation, Hutchins countered that human "cognition is a fundamentally cultural process" that cannot be isolated for study in a laboratory setting. For Hutchins, human cognition was inextricably tied to the materiality of the tools and symbols that humans use when they perform a task, and the social relationships present in the environments in which they perform those tasks. As Hutchins remarked in a later paper, "The meanings of the parts are derived from the meanings of the whole rather than the other way around."[53]

To illustrate his point, Hutchins relied on anthropologic and ethnographic methodologies applied to a finely detailed example of maritime navigation. He concluded that the tools used in navigation, such as charts, chronometers, compasses, and navigation logs, were inseparable from the task of navigation itself. Indeed, he claimed that "we cannot know what the task is until we know what the tools are," including the "relationships among

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[52] The field of engineering systems is focused on understanding the attributes and performance of large, complex, socio-technical systems. More specifically, *engineering systems* is defined as the "nexus of engineering, management, and the social sciences" that yield "a class of systems characterized by a high degree of technical complexity, social intricacy, and elaborate processes, aimed at fulfilling important functions in society." de Weck, Roos, and Magee, *Engineering Systems*, 1, 31.

[53] Hutchins, *Cognition in the Wild*, 374; Hutchins et al., "Integrative Approach to Understanding Flight Crew Activity," 357.

them." But Hutchins also cautioned his readers not to exaggerate the importance of the tools at the expense of the operator, explaining that it was not the tools that provided the "computational power of the system," but rather the human's use of those tools in the specific setting. In the end, Hutchins argued that the capacity to perform a desired task—"expertise"—resided neither in the technological tools nor in the human operators, but rather in "the *system* of person-in-interaction-with-technology."[54]

But, what happens when the machinery required to complete a task purports to obviate human involvement in that task? For example, in Hutchins's descriptions of maritime navigation and his reports of sailors mounted around a ship's bridge taking bearings to landmarks, shouting their readings to other sailors hunched over charts at a navigation table, it is easy to visualize individuals using and interacting with their technological tools, as rudimentary as a compass, ruler, and pencil may be. But what of more automated systems, such as the fire control systems and "electronic brains" that began to appear on fighter aircraft in the 1950s? These systems were embraced by the military precisely because they promised to take the human pilot "out-of-the-loop," limiting his interactions with the system and, consequently, his potential to corrupt the "expert" system's performance and reliability.[55]

It is here that Thomas Sheridan's body of work, notably *Telerobotics, Automation, and Human Supervisory Control*, provides additional insight. In it, Sheridan argued that viewing increasing automation as a contest that pitted "humans versus robots" was "simplistic, unproductive, and self-defeating." Instead of the dichotomous human or machine distinction, Sheridan encouraged his readers to consider instead the possibilities of "cooperative" interaction, or what he termed "telerobotics or supervisory control." Later, Sheridan would further refine his ideas and codify a spectrum of human-machine interaction, ranging from strictly manual systems characterized by direct human control to highly automated systems characterized by little-to-no direct human control.[56]

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[54] Hutchins, *Cognition in the Wild*, xv, 114, 155. Emphasis added. Hutchins also noted that the "accumulation of structure in the tools of the trade is itself a cognitive process," and one that is "historically contingent." See also the texts on actor-network theory, which encourages researchers not to draw artificial distinctions between human actors and the technologies they develop and operate, notably Latour, *Science in Action*.

[55] Smith, "Pilots or Robots?"; Schenk, "Not Pilots or Robots"; Hoover, "Place in the Sun."

[56] Sheridan, *Telerobotics, Automation, and Human Supervisory Control*, xvii; Parasuraman and Sheridan, "Model for Types and Levels of Human Interaction."

Surveying multiple applications, however, Sheridan observed few examples of total automation. Rather, usually a human observer exerted some type of supervisory or remote control over the automated system, monitoring its performance and standing ready to intervene if required. Sheridan in part attributed the supervisor's presence to the system architects' requirements to "add novelty and creativity [in decision-making]—precisely the ingredients that cannot be prespecified" in an algorithm.[57] But, even in these highly automated cases where the supervisor's interaction with the system was greatly reduced, significant human-machine interaction still takes place; investigating it just requires a wider aperture in time and space. Someone (or some group) had to predict the likely circumstances the system would face and then code the necessary and appropriate decisions into the automation algorithm. Although that individual may be far removed from the system when it is put into service, he or she nonetheless represents a critical component. Hence, when encountering systems that possess high levels of automation, Sheridan reminds us that it is necessary to extend our investigation of the human-machine interactions beyond that of the immediate individual standing near a control panel.[58]

The final author, Richard Sennett, provides a philosophical link between Hutchins and Sheridan relevant to this dissertation project. Whereas Hutchins focused on the materiality and human-machine interaction within the task-based, cognitive environment, Sennett's *The Craftsman* addressed the human and social elements that shape the design and construction of an artifact. Sennett argued that "thinking and feeling are contained within the process of making," and that "people can learn about themselves through the things they make." On the surface, his statements appear intuitive, almost simplistic. However, Sennett was retorting several scholars that argued the alternative: that those responsible for making material artifacts remain somehow divorced from the ends their products eventually serve; that "the mind engages once the labor is done." For Sennett, those that craft an artifact are engaged in an implicit discussion with their creation as they encounter "the difficulties and

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[57] Sheridan, *Telerobotics, Automation, and Human Supervisory Control*, 314, 358–60. See also Sheridan's discussion of Roseborough's Dilemma, which suggests that "in any system requiring a human operator, the objective validity of a specific decision aid can never be established."

[58] When examining highly automated systems, Mindell likes to ask: "Who are the people, where are they, and what are they doing?"

the possibilities of making things," and, importantly, this discourse mirrors that found in human social relationships. [59]

Of particular note is Sennett's discussion of the conflict between the image of the procedurally driven professional and that of the skillful artisan or craftsman. For example, Sennett noted that since the nineteenth-century, the machine has represented the "movement from hands-on knowledge to the dominant authority of explicit knowledge.... Against the rigorous perfection of the machine, the craftsman became an emblem of human individuality," with all the accompanying "variations, flaws, and irregularities." However, to disabuse the *craftsman* term of its connotations as blue-collar or lesser status as compared to a *professional*, Sennett invited his reader to consider the instances when a tool is suddenly realized to be imperfect or incomplete. He suggests that a craftsman thrives in this environment, profiting from "the experimental rhythm of problem solving and problem finding" that supports his improvisation and creativity. This is in sharp contrast to those whose lives are rooted in "mindless procedure" which provide neither little accommodation for human individuality or distinctness, nor any time for the human to pause and reflect on one's work or the ways to improve it.[60]

Hence, each of the three authors—Hutchins, Sheridan, and Sennett—offers critical insight to my investigation of fighter pilots' reactions to more complex, more automated, and more procedurally driven fire control systems. Hutchins validates the human-and-machine perspective and reminds us of its importance. Sheridan helps us locate the human interactions when encountering the more automated systems. And Sennett provides us with a new way of conceptualizing the role, activities, and the purpose of the creative *craftsman* as distinct from the rule-abiding *professional*. But, lest we become too enamored with Sennett's exaltation of the individual, we return again to Hutchins's admonishment that we should not

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[59] Sennett, *Craftsman*, 6–8, 289.

[60] Ibid., 26, 84, 286–96. For an earlier expression of this sentiment, see Mumford, *Technics and Civilization*. Of note, Sennett's description of a *professional* differs from that developed by Abbott. Abbott distinguished "crafts" from "professions" based on the latter's "control of the occupation ... [through] control of the abstractions that generate the practical techniques." This allows the "techniques" to then be "delegated to other workers" while retaining the profession's ability to "redefine its problems and tasks, defend them from interlopers, and seize new problems" by adjusting its "abstract" knowledge structure. In contrast, Abbott argued that within the "crafts," a "group directly controls its technique" in order to maintain control over the occupation. Abbott, *System of Professions*, 8–9. However, Sennett's use of the term *professional* is congruent with that of the "rank-and-file professional" whose autonomy is often curtailed by organizational management and the allocation of resources, as described by Freidson, *Professional Powers*, 154–55. Both Freidson and Abbott acknowledge the difference in status between the professional and the craftsman that Sennett references.

privilege study of the individual human operator at the expense of his or her tools or the surrounding environment. The three authors' arguments therefore both illuminate and balance that of the others.

A small but growing constellation of scholarly research has used this socio-technical, human-and-machine perspective to investigate complex systems during periods of technological change, but none in the realm of fighter aviation with its attendant powerful and timeless myth. For example, David Mindell used the approach to study both Civil War sailors aboard the ironclad USS *Monitor* and NASA astronauts descending to the lunar surface in their Apollo spacecraft.[61] To better understand the Air Force's new Remotely Piloted Aircraft (RPA), Tim Cullen directed attention to the RPA's pilots and sensor operators and their interactions with their purportedly "unmanned" and "autonomous" aircraft.[62] Ray O'Mara took a similar approach when studying the technologies and doctrine of strategic bombing during World War II, electing to investigate the actions of a flight crew on a B-17 Flying Fortress during a typical bombing mission.[63] In each of these studies, the authors developed a rich ethnographic understanding of operators using their equipment, which yielded new insights into the opportunities and challenges present in complex human-machine systems. In Cullen's case, direct observation yielded the necessary data, but for the others, historical research was used to successfully develop their "thick narratives."[64]

I follow the general course charted by Mindell and O'Mara, supported by Hutchins, Sheridan, and Sennett, and similarly apply a human-and-machine perspective and ethnographic approach to develop a cognitive history of USAF fighter pilots in the period 1950 to 1980.[65] This thirty-year span represents a significant shift in the air combat environment, from the guns-only dogfights of the Korean War to the missile-dominated air combat exercises that produced the tactics eventually used in Desert Storm. Within this time

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[61] Mindell, *War, Technology, and Experience*; Mindell, *Digital Apollo*.

[62] Cullen, "MQ-9 Reaper Remotely Piloted Aircraft."

[63] O'Mara, "Socio-Technical Construction of Precision Bombing."

[64] The concept of developing a "thick narrative" through ethnographic research is associated with Geertz; it is a process of making sense of "a multiplicity of complex conceptual structures, many of them superimposed upon or knotted into one another, which are at once strange, irregular, and inexplicit." Geertz, *Interpretation of Cultures*, 10, 16. For another example of using an ethnographic approach to gain insight into the workings of a complex human-machine system, see Clancey, *Working on Mars*.

[65] As a former F-15C fighter pilot, I bring a participant-observer's insider knowledge to the discussion, not of the specific period under study, but of its after effects and legacies in the fighter pilot community.

span, I examine three aircraft and the community of pilots that flew them; each symbolizing air-to-air combat in their respective decade—the F-86E Sabre of the '50s, the F-4C Phantom II of the '60s, and the F-15A Eagle of the '70s.[66] Moreover, each of these aircraft possessed weapons systems that were a generational improvement over their immediate predecessors, and in each case the pilots were confronted with new gadgets and increasing automation intended to make them more lethal in air-to-air combat and at the same time less dependent on innate, physical skill. But what did these new technologies mean for the individual fighter pilot climbing into his plane, donning his helmet, and blasting off into the sky?

A Brief Overview

I tell the story chronologically, beginning in Chapter 3 with the introduction of radar technology to small, single-seat fighter aircraft. For those sitting in the cockpit of the F-86 Sabre, a new radar-ranging gunsight would, according to Air Force engineers, finally allow "the pilot to direct his full attention to the selected target."[67] Using the radar to precisely measure the distance to an enemy target, and then automatically feed that information into a mechanical computer, the new A-1C(M) gunsight promised to eliminate the requirement for fighter pilots to be crack marksmen skilled in applying "Kentucky windage." Henceforth, they would only need to place the A-1C(M)'s aiming pipper over the target and squeeze the trigger, leading the *New York Times* to boast that the new "secret radar sight … does everything but fly the plane."[68]

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[66] The F-86A/E and F-4C/D/E all saw extensive use in combat. The F-15A, however, did not; its slightly modified successor, the F-15C, was the predominant air-to-air aircraft in Desert Storm. Unfortunately, because the F-15C is still actively used by the Air Force, many of its systems remain classified, as do the specific F-15 combat reports from Desert Storm. Hence, in an effort to avoid these classification issues, I terminate my study with the F-15A. To compensate for the lack of combat data, I rely on a pair of tests conducted in 1977 that were lauded as being the most realistic air combat tests ever devised.

There were obviously other technologically advanced aircraft fielded by the Air Force during this 30-year period; for example, the Air Force's century-series of fighters, which included the F-100, F-101, F-102, F-104, F-105, and F-106. However, none of these aircraft saw the *air-to-air* combat experience of the F-86, F-4, or F-15. Additionally, interceptor aircraft like the F-102 and F-106 were assigned to Air Defense Command (ADC) and were flown by "interceptor pilots," not "fighter pilots." The fact that the former wore orange flight suits, as opposed to the latter's olive-drab flight suits, was a visible distinction separating the two. See the discussion in Chapter 4.

Finally, I focus on the air-to-air aspect of fighter combat, as opposed to the bomb-dropping air-to-ground component, because it remains directly linked to the early celebrated experiences of the early great aces like Boelcke, Richthofen, and Rickenbacker. See the discussion in Chapter 2.

[67] *A-1 Series Sight*, 2.

[68] "New Radar Sight Guides Jets' Guns."

However, when the revolutionary gunsights were rushed into Korean combat in mid-1951, three deficiencies with the concept quickly emerged. First, the Sabre pilot still had to visually detect the enemy. Second, the pilot needed to be skilled enough to maneuver into position behind his selected foe for the gunsight to compute a solution. Lastly, his Sabre jet had to possess sufficient maneuverability, speed, and altitude performance, relative to the adversary, to facilitate his gaining and maintaining the offensive position. As the Sabre pilots and their commanders quickly realized, none of these prerequisites were routinely assured in the skies of MiG Alley, and in their absence, the improvements in the new radar-ranged gunsights were for naught. Reflective of the pilots' mounting frustration, Colonel Francis "Gabby" Gabreski, a Sabre wing commander in Korea and the top American ace from World War II's European theater, once reportedly remarked that he preferred to use "a piece of chewing gum in the windshield" as an aiming reference rather than rely on the heavy, complex, and seldom-functioning A-1C(M) gunsight.[69]

Chapter 4 investigates the new concept of air combat that emerged following Korea. Instead of relying on a pilot to maneuver his aircraft into an offensive position behind an enemy airplane, engineers asked why not shift that difficult task to a guided missile? Although simple in principle, it was not an easy engineering task. Engineers would need to develop, in addition to the missiles, a radar that was powerful enough to guide the missiles to the target but that was also compact and light enough to fit in a small fighter aircraft. In 1955, the engineers working on the Navy's new F4H Phantom II aircraft, which was later adopted by the Air Force, embraced the challenge. Two years later, the AIM-7 Sparrow radar-guided missile had become the Phantom's primary armament and the venerable gun had been stripped from the aircraft's design.[70] Although it later became popular to vilify the engineers and acquisition desk jockeys for their faith in the unproven missile armament, at the time many American pilots, still haunted by memories of MiGs soaring high above them near the Yalu and out of reach of their .50-caliber machine guns, supported the shift from anachronistic guns to modern missiles.[71]

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[69] Wildenberg, "A-1C(M) Gunsight," 35; Werrell, *Sabres Over MIG Alley*, 30.

[70] Bugos, *Engineering the F-4*, 11–12, 27–28. Although technically the Phantom II—the original FH-1 Phantom first flew in January 1945—most referred to the latest incarnation simply as the Phantom.

[71] Michel, *Clashes*, 13.

Other aspects of the Phantom design weren't as well received. Engineers determined that it would be unrealistic to saddle the pilot with the additional tasks associated with the Phantom's complex radar and avionics.[72] Hence, the Phantom would forever be a two-seat fighter: the pilot in the front seat would worry about flying the plane and launching the missiles; the back seat occupant, commonly referred to in Air Force circles as the "GIB" or "guy in back" would be responsible for operating the radar. Although some prior Air Force fighter planes had used a two-person crew, the mere presence of the second crewmember in the Phantom's cockpit was a serious affront to the iconic fighter pilot image. To fly a single-seater was for many fighter pilots a badge of honor that could be traced back to the legendary aces of World War I, and several fighter pilots in the 1960s therefore opted to fly outdated F-100 Super Sabres and F-105 Thunderchiefs rather than subject themselves to the ignominy of sharing their cockpit with another.[73]

Additionally, the Air Force's version of the Phantom was a multi-role airplane. Consequently, for the fighter pilots seated in the cockpit, that F-4's versatility translated into requirements to become an expert in not only air-to-air combat tactics, but also in a variety of air-to-ground missions and the dizzying array of bombs and rockets used to execute them. When thrust into combat over Vietnam, it was in fact pilots' aptitude at dropping bombs that was more often put to the test rather than their skill in an air-to-air engagement. But when they did have a chance to tangle with a MiG, the Phantom pilots cherished it as a rare opportunity to dispense with the "rubbish" of Washington-dictated bombing targets and become once again a fighter pilot in the spirit of the great Red Baron. As World War II fighter ace and later storied Phantom pilot Brigadier General Robin Olds explained of his time flying in Vietnam, air combat was "the most exciting. You can get your adrenaline pumping in air-to-air like you would not believe.... It is a one-for-one thing, really.... You feel very personal about that son of a bitch that is trying to kill you.... It is every fighter pilot's dream."[74]

The fighter pilots in the F-4 had to navigate new relationships with novel technologies, another human crewmember, and a variety of new missions. In the case of the F-15 discussed in Chapter 5, the fighter pilots had a simpler task: they only had to worry

[72] Bugos, *Engineering the F-4*, 26.

[73] Wohl, *Passion for Wings*, 207–8, 214; Creech, Oral History Interview, 54; Wallace, interview.

[74] Olds, Corona Ace Oral History Interview, 65–66.

about new technologies. There was no second crewmember and there was no second mission. The sleek F-15 was designed for one thing only—prevailing in air-to-air combat. That design philosophy, a retort to the "jack of all trades but master of none Phantom," was reflected in a popular saying still echoed by Eagle enthusiasts today, "not a pound for air-to-ground."[75] Moreover, maximum maneuverability, not top speed or altitude ceiling, became the critical performance metric for the Eagle; the fighter pilots advising on the F-15 design didn't want to be out-turned again in a future dogfight. Importantly, unlike the early F-4 Phantoms, the F-15 would have an internal gun so that the Eagle pilot could carry any swirling attack to its proper fiery finale.[76]

Air-to-air guided missiles would provide the Eagle's primary punch, as they had on the earlier Phantoms, but the F-15's armament system represented a significant improvement over that of the F-4. In particular, the F-15's new radar was larger and more powerful, capable of detecting targets flying at any altitude and at longer ranges. While the F-15 was intended to be more a dogfighter than a missile-hurling interceptor, the pilot would still need to operate the more advanced radar to detect targets and then maneuver into an ideal attack position, and he would need to do so without the benefit of the second crewmember that had previously been trained to operate it. To resolve the engineering paradox, the F-15 designers chose to introduce greater automation and better mechanization of the fire control system into the Eagle cockpit.

The Eagle's new HOTAS (hands on throttle and stick) concept and HUD for the pilot represented the critical components of the engineers' solution. HOTAS allowed the pilot to control most of the aircraft's radar and weapons functions without him having to take his hands off the aircraft controls—no more fumbling for switches in the heat of battle. The HUD in turn allowed the pilot to see all the relevant weapons information without having to divert his glance from his target.[77] The new setup, one information brochure proclaimed, "allows the pilot to 'keep his head out of the cockpit' and frees him to press the attack during critical phases of combat," a curious echo of the prediction that greeted the

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[75] Davies, *F-15C Eagle Units in Combat*, 7; Werrell, *Chasing the Silver Bullet*, 63; Welch, interview, October 1, 2013.

[76] Coram, *Boyd*, 204; Werrell, *Chasing the Silver Bullet*, 60–61, 64–66, 70.

[77] Anderegg, *Sierra Hotel*, 153–154; Werrell, *Chasing the Silver Bullet*, 70; Anderegg, interview, April 9, 2013; Wallace, interview.

fielding of the A-1C(M) in the F-86 Sabre decades earlier.[78] Equipped with its powerful radar that could stare down the enemy at long range, but more importantly, with its exceptional maneuverability and its internal gun for close-in combat, along with the fact that there was only a single seat in the cockpit, the Eagle was heralded as the "fighter pilot's fighter."[79]

But just as the Eagle started to populate Air Force flightlines, a pair of Congressionally mandated joint Air Force-Navy flight tests conducted in 1977, the Air Intercept Missile Evaluation (AIMVAL) and the Air Combat Evaluation (ACEVAL), challenged the preeminence of many of the F-15's technologies. Reminiscent of the high-flying MiGs in Korea that had reduced the combat significance of the Sabre's novel gunsight, the new "forecasted threat" that was used during the evaluations threatened to quash some of the Eagle's technological advantages. Specifically, new all-aspect, infrared (IR)-guided missiles used by the adversary aircraft proved especially lethal to the tennis-court-sized F-15 in a turning dogfight.[80] During the tests, the Eagle pilots concluded that they would have to concentrate more heavily on developing tactics and technologies that were optimized for long-range air combat rather than continuing to focus on the short-range dogfighting that they enjoyed.[81] One of those subsequent improvements in long-range tactics was the pre-coordinated "sorting" plan that Sveden and Prather relied on to down their pair of Iraqi fighter jets in Desert Storm.

The Argument: Technological Enthusiasm and Hidden Challenges

As the history makes plain, the Air Force during this period exhibited an unswayable faith in new technologies and the air combat advantages they promised. When deficiencies were revealed, they became a new technological hurdle or, in Thomas Hughes's words, a "reverse salient" for engineers to conquer.[82] For example, when the guns on the F-86

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[78] *Eyes of the Eagle*, 2.

[79] Hoag, "Superfighter," 21.

[80] Blesse, "Changing World of Air Combat."

[81] Griffith, "AIMVAL-ACEVAL"; "No-Win War at Dogbone Lake"; Anderegg, *Sierra Hotel*, 158–61.

[82] Hughes introduced the term "reverse salients" to describe "components in the system that have fallen behind or are out of phase with the others." Hughes, "Evolution of Large Technological Systems," 73. MacKenzie expanded on Hughes's concept: "System builders typically focus inventive effort, much like generals focus their forces, on the elimination of such reverse salients; they identify critical problems whose solution will eliminate them.... But it may not always be clear where progress is being held up, nor what should be done about it. Even with agreement on goals, ... the nature of the obstacles to the achievement of these

couldn't shoot down the high-flying MiGs, the engineers turned to higher-flying missiles to replace the guns. And when the F-4's missiles and radar didn't meet expectations in Vietnam, engineers sought a bigger radar, improved missiles, and new weapons system automation and mechanization for the F-15. No wonder the "great machine" narratives and the accompanying accusations that "The Air Force has long worshipped at the altar of technology" are so pervasive.[83]

However, there is also another component of "technological enthusiasm" embedded in the story that reaches beyond the simple "means-ends" relationship that guided the weapons system designers and their efforts to enhance the lethality of the fighter pilot. For many of the pilots who were clamoring to fly the new aircraft, their enthusiasm was tied not to the new technologies' purported Communist-vanquishing power, but rather to the sheer thrill of strapping on sleeker and more powerful aircraft and thundering off into the wild blue yonder. Be it flying the F-86 in 1950, the F-4 in 1965, or the F-15 in 1975, fighter pilots' "eager embrace of the means" was akin to that observed by David Lucsko of hotrodders and car enthusiasts, and not "necessarily predicated on specific ideas regarding the ends [the means] might deliver."[84] The aircraft functionally provided a platform for the weapons systems to shoot down enemy aircraft, but pilots rarely saw their aircraft that way.

Instead, to fly these aircraft was to be given the figurative keys to the service's most modern and most exciting fighters.[85] Evans once reflected, "I don't suppose there was ever a fighter that was such a pure delight to escape with into the wild blue as the F-86 Sabre.... Gazing back along those first swept-wings, one could imagine all sorts of exciting possibilities."[86] While few Phantom pilots would ever use such glowing terms to describe the F-4's flight characteristics—it was a common joke that "the F-4 represent[ed] a triumph of thrust over aerodynamics"—Phantom pilots nevertheless quickly developed their own

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goals and the best means of removing them may be the subject of deep disagreement." MacKenzie, *Inventing Accuracy*, 79–80.

[83] Builder, *Icarus Syndrome*, chap. 14.

[84] On the potential ambivalence in the means-ends relationship and the corresponding "extraordinary power that enthusiasm for a particular technology *in and of itself* is capable of exercising," see Lucsko, *Business of Speed*, 8. Emphasis in original.

[85] The image of modernity has always been a critical component to the mystique of aviation. See, for example, Schatzberg's concept of an "ideology of progress" guiding aviation's transition from wooden aircraft to metal aircraft. Schatzberg, *Wings of Wood*.

[86] Evans, *Sabre Jets Over Korea*, 234.

special bond with their steed.[87] For example, one Phantom pilot described the F-4 as "the world's greatest tactical toy, filled with all kinds of 'gee charlie whiz bangs' designed to make any fighter pilot go into a state of terminal ecstasy."[88] When the F-15 arrived on-scene, pilots could once again boast of flying a beautiful airplane, and an unbelievably powerful one, too. Describing his transition from the Phantom to the Eagle, one early F-15 pilot likened it to "going from an F-150 pickup truck to a Corvette."[89] Another exclaimed, "To say that the Eagle's afterburner takeoff was impressive would be an understatement of the highest order.... What we have here is truly a Superfighter."[90]

But when used in combat, or simulated combat, these same thrilling aircraft also presented significant challenges to the historic notion of what it meant to be a fighter pilot. No longer were pilots to be judged primarily on their physical attributes such as good eyesight and stick-and-rudder finesse. Instead, success now depended upon a fighter pilot's ability to control complex and finicky pieces of electronic hardware. Air combat was being transformed from the celebrated close-range aerial duel between two lone chevaliers into an assassin's duty whose outcome depended solely on the procedures-driven checklists that supposedly delineated step-by-step how to use the radar and shoot the missiles. Lured into the service with images of becoming "America's Knights of the Sky," fighter pilots began to worry that they were at risk of becoming simply another "black box" in the aircraft or being transformed into "long-haired" scientists and systems managers (figures 1.2, 1.3, and 1.4).

Yet pilots needed to be part-scientist, part-systems manager just to understand how their new complex systems functioned. Evans once complained during the Korean War that "a pilot today is expected to know all the complexities of every system in his bird: electric, hydraulic, fuel, oil pressurization, *ad infini-tum*."[91] However, the technical knowledge requirements of an F-86 pilot paled in comparison to what was later demanded of F-4 and F-15 pilots. Evans's flight manual for his F-86E weighted in at about 250 total pages, of

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[87] McCarthy, *Phantom Reflections*, 16; Handley, *Nickel On The Grass*, 66. Handley notes: "It has been said: '

[88] Trotti, *Phantom over Vietnam*, 27.

[89] Quoted in Anderegg, *Sierra Hotel*, 150.

[90] Hoag, "Superfighter," 23.

[91] Evans, *Sabre Jets Over Korea*, 170. Emphasis in original.

Figure 1.2. "America's Knights of the Sky" Recruiting Advertisement.
(Source: *Air Force*, May 1954)

which about thirteen pages were devoted specifically to the Sabre's armament equipment.[92] And even then, despite Evans's lamentations, most Sabre pilots of the period openly boasted of their disregard for their flight manuals and checklists—a *true* fighter pilot didn't need to rely on those crutches, he would just intuitively know how to fly the plane.[93] In contrast, to fly the F-4, pilots had to slog through a 518-page flight manual, plus an extra 406-page second volume devoted solely to the Phantom's complex armament systems.[94] Although

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[92] *T.O. 1F-86E-1*. The armament equipment information is located on pages 4-22 through 4-34.

[93] Werrell, *Sabres Over MIG Alley*, 58.

[94] *T.O. 1F-4C-1*; *T.O. 1F-4C-34-1-1*. The -34 series manuals did not appear until 1964, a reflection of the growing technical knowledge requirements associated with the more complex aircraft and the wider variety of armament they carried. Winkler, "Look at the -34 Aircrew Non-Nuclear Weapons Delivery Manual."

some Phantom pilots may have tried at first, they quickly realized that they couldn't bluff their way through their manuals or checklists. A fighter pilot now had to complement his flying skills with book-smarts and intense study.

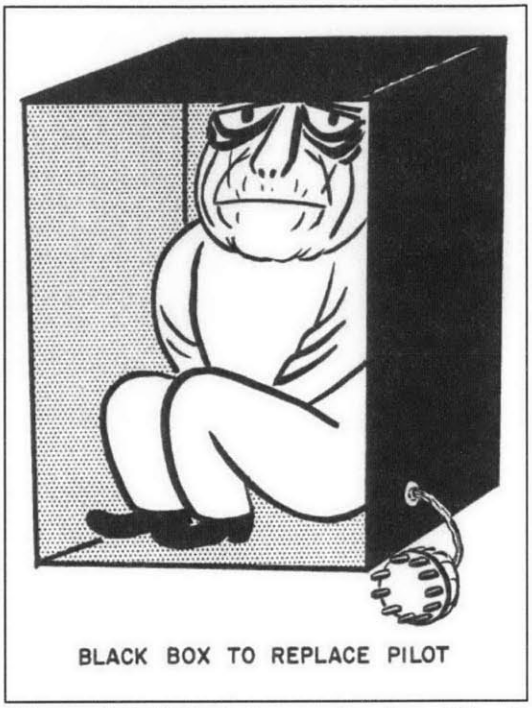

Figure 1.3. "Black Box to Replace Pilot." (Source: *Fighter Weapons Newsletter*, Sep 1959)

Additionally, despite the aircraft becoming more powerful and more complex, the mere act of flying them was actually becoming less demanding. Novel aerodynamic designs and new control systems yielded aircraft that possessed better, smoother flight characteristics. For example, whereas the Phantom was notorious for its sudden, violent, and often deadly spins, even test pilots wringing out the first F-15s had a difficult time forcing them out of control.[95] One former Eagle fighter pilot remarked in a later interview that given a few hours training in a simulator, a six-year old could have flown the Eagle.[96] If traditionally a pilot's skill and bravery was affirmed by his willingness to take to the air in a machine that threatened to kill him the moment his concentration broke, would the emergence of these safer and easier-to-fly aircraft reduce the fighter pilot's heroic stature?

Figure 1.4. "Long Haired Corner." This section of the *Fighter Gunnery Newsletter* was devoted to technical concepts. This issue's topic was "Electronics: Maintenance technique for the APG-30 Radar set." (Source: *Fighter Gunnery Newsletter*, Jan 1954)

[95] *USAF F-15 Fighter Summary*, 7; Lewis, *History of the F-15 Eagle*, 48, 85.

[96] Anderegg, interview, October 2, 2013.

Other traditionally valued pilot traits likewise diminished in significance as new aircraft and new weapons systems proliferated. Take, for example, the value of better-than-perfect vision. In World War II, Chuck Yeager earned a reputation for seeing the enemy long before anyone else, and he excelled in the skies over Europe because of it.[97] But by the time of Desert Storm, it didn't matter "how thick the guy's glasses were."[98] Now, the measure of a good pilot wasn't so much who could spy distant specks on the horizon, but who could look at their four-inch square radar scope and most quickly and accurately transform its abstract symbology into a three-dimensional thirty-mile mental "picture" of the airspace ahead.

These shifts in fighter pilots' skillsets demanded new tools to document the pilots' performance in the air. It was for more than just male egotistic self-aggrandizement. Pilots needed to know which of their comrades was most successful so that they could mimic that pilot's tactics. Historically, the universal measure of a pilot's performance in air-to-air combat was the aerial victory, a.k.a "the kill," often annotated on the side of the victor's fuselage by a small star, enemy flag, or enemy aircraft silhouette. In World War II and Korea, gun cameras mounted in an aircraft's nose were used to document the victory, recording the images of an enemy aircraft disintegrating ahead under a steady stream of straight-flying bullets.[99] During training missions, the same gun camera was used to document the pilot's performance as he maneuvered into an offensive position and gunned down an aerially towed target banner.[100] But with the advent of long-range missiles that could turn and seek out the enemy, kills rarely occurred directly out in front of the attacking fighter and in view of the fixed-position gun camera. Moreover, the complex missiles were becoming increasingly expensive, so firing them off just for practice quickly became infeasible. And, with the missiles often suffering from their own internal catastrophic failures independent of pilot action, their ability to hit a target successfully was beginning to lose its relevance as a fair measure of pilot performance.

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[97] Yeager, *Yeager*, 41–43, 53–54, 58–59.

[98] Welch, interview, October 1, 2013.

[99] See, for example, the gunnery footage in the following WWII newsreels: *Gen. MacArthur Leads Attack on Admiralty Islands; Allied Drive on in Italy.*

[100] See discussions on towed target shooting in: "A-1 Sight and Air to Air Gunnery"; "Gun Camera"; "How to Set Up a Film Assessing Room"; "Lead Assessing"; Giordano, "Dart Target," November 1956; Giordano, "Dart Target," March 1957; Bond, "Elusive Dart."

Consequently, reflecting the growing interconnectedness of the system components, new data needed to be collected and analyzed to assess a pilot's skill and performance in the air.[101] For example, based on the preeminence of the radar missile and the lack of an internal gun in the Phantom's design, the traditional forward-looking gun camera was replaced with a camera that recorded the back seater's radar display. To augment the images of the radar screen, pilots also began recording the aircraft and cockpit communications, particularly the discussions between the pilot and his GIB. The Phantom, however, lacked the voice recording capability, so many F-4 pilots improvised and simply started carrying personal portable cassette recorders in their flight gear, which they patched into the radio cord that connected the headset in their helmet to the aircraft.[102]

With its internal gun and emphasis on close-range combat, a forward-facing gun camera was once again required for the new Eagle. Rather than mount the camera in the nose of the aircraft, engineers positioned it inside the cockpit and had it take pictures through the HUD display. This allowed F-15 pilots to record both the image of a glorious fireball and the weapons parameters, as displayed in the HUD, that yielded the victory. Pilots still needed to carry portable voice recorders, though, to capture the radio coordination that was becoming increasingly important in air combat.[103] They also had to try to remember how the engagement began and the spatial relationships of the various aircraft that were outside the HUD's field of view. A later recording system introduced during AIMVAL (Air Intercept Missile Evaluation) and ACEVAL (Air Combat Evaluation) known as ACMI (Air Combat Maneuvering Instrumentation) addressed some of these limitations by actually downlinking the aircraft positions, attitudes, and weapons parameters to a ground station that could display and record the three-dimensional engagement. Using the real-time data and the actual weapons parameters during simulated missile launches, the ACMI computers determined the likelihood that a simulated missile would result in a kill, and if so, the ground

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[101] Hutchins et al., "Integrative Approach to Understanding Flight Crew Activity." Hutchins observed that "to study activity as an integrated system, we need tools that allow us to look at multiple sources of data about the activity in a synchronized and integrated way." The fighter pilots came to this realization in a practical manner.

[102] Harmer and Anderegg, *Shootdown of Trigger 4*, 5; Futrell et al., *Aces and Aerial Victories*, 20–22; Anderegg, interview, April 9, 2013; Sokol, interview.

[103] Sokol, interview; Wallace, interview.

observers would, in a God-like voice, announce over the radio, "Blue 4 [or the appropriate callsign], you're dead."[104]

All told, with fighter pilots delving into the books to learn about electromagnetic theory for their radars, lambda-angles and English-bias for their missiles, and measuring success not with images of enemy aircraft erupting into balls of flame but with schematic coffins appearing over a computer-generated recording of an aerial engagement, were the modern fighter pilots that far off from being flying scientists?[105]

There is another oft-overlooked component to the story. In addition to the shifting human-machine dynamics occurring within the fighter cockpit, there were significant changes taking place in the human-machine relationships between fighter cockpits.[106] Although often portrayed as lone eagles patrolling the skies, fighter pilots since the middle of the Great War understood the advantages of flying together in a formation. Hence, by 1922, an American Army Air Corps manual had already declared "the 'ace' … as passé a phenomenon as the champions of Homer."[107] Flight training programs consequently began to emphasize the importance of sticking together in the air, and emerging tactical doctrine assigned specific responsibilities to the wingmen and the leaders in a formation.[108] The more experienced flight leader was supposed to shoot down the enemy. The younger, less experienced wingman was there to watch and learn from the leader, to occasionally serve as bait, and to always defend the leader from attack. Survival as a wingman proved that one possessed the requisite fighter pilot skills needed to become a successful flight leader.

When Evans took to the skies as a wingman in his Sabre, his responsibilities and the position he flew were remarkably similar to those developed decades earlier. Although now

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[104] Taylor, "Air Combat Maneuvering Instrumentation"; Turner, "ACMI Update"; Waddell, "ACMI Improves Pilot Combat Training."

[105] Lambda referred to the angle between the infrared-detector unit and the missile body in the Sidewinder missile; the pilot had to ensure that the lambda-angle was less than fifty-degrees at launch for the missile to work. English bias was an early guidance improvement to the Sparrow radar missile. *8th TFW Tactical Doctrine*, March 1967, 85; *T.O. 1F-4C-34-1-1*, 1–34.

[106] Of note, O'Mara explored the impact of changing aircraft technologies on the tactical formations flown by B-17s in World War II. O'Mara, "Socio-Technical Construction of Precision Bombing."

[107] Milling, *Air Tactics*, 1–9.

[108] Doctrine has been described as the "glue" that holds a human-machine system together, mediating between the two components to prescribe how a specific task is to be accomplished. Within the military, there are multiple layers of doctrine. At the highest level, *strategic* doctrine outlines how the military plans to use its forces to win a war. *Tactical* doctrine operates at a lower-level, outlining for example how a handful of fighter pilots should work together as a formation team to accomplish a mission. O'Mara, "Socio-Technical Construction of Precision Bombing," 345. For a different definition of *doctrine*, see Posen, *Sources of Military Doctrine*.

rarely used as bait (the lower- and slower-flying bombers served that role), the wingmen in Korea were still expected to place themselves in between their leader and an attacking enemy. Moreover, the wingman's service to his flight leader didn't end when the aircraft touched down after a mission. William Brown, who would later retire as a three-star general, recalled running errands around the base for his Sabre flight lead.[109]

But with the greater offensive potential afforded by the new fire control systems and longer-range weapons on the Phantom and Eagle, relegating a wingman to this strictly defensive, subservient role was also becoming passé. A handful of fighter pilots proposed eliminating the close-in "fighting wing" position, with its corresponding rigid flight lead-shooter and wingman-looker assignments, but they encountered stiff resistance from within the fighter pilot ranks. With young, inexperienced wingmen possessing greater offensive autonomy, many flight leads worried that formations would become too difficult to manage.[110] The newly proposed formations would also demand a new level of mutual dependence between the flight lead and his wingman. It would, fighter pilots feared, undo their forty-year old social structure, institutionalized in the formations that they flew. Hence, investigating this controversy over the community's tactical doctrine and their formations adds a layer of richness to our understanding of human-machine relationships in periods of technological change. It was not just individual pilots that had to contend with altered tasks and identities, but also the social contracts and hierarchy that governed their life as a fighter pilot.

One Perspective: Viewing Fighter Pilots as Professionals and as Craftsmen

In the midst of this technological and professional upheaval, officials at Tactical Air Command (TAC), the home to the majority of Air Force fighter pilots, reported to the Pentagon in mid-1963 that a major public relations concern of theirs was the image of the TAC fighter pilot. They pleaded with their leaders in Washington to help them "reshape the image of the World War II fighter pilot … to the educated, stable, mature, versatile and devoted individuals required in the nuclear era, who are dedicated to doing their jobs with all

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[109] Hallion, "Air Dominance," 30.

[110] Michel, *Clashes*, 169–72; Anderegg, *Sierra Hotel*, 59–60; Anderegg, interview, April 9, 2013; Anderegg, interview, October 2, 2013; Sokol, interview; Wallace, interview.

responsibilities and self-sacrifice readily accepted.... The objective is to point up that *the TAC crew is not and has not been the irresponsible 'buzz boy' fighter pilot as seems to be thought.*"[111]

TAC wanted its pilots to be seen as "real professionals," and although they did not suggest how to effect this transformation, they enviously cited the image of Strategic Air Command (SAC) under the leadership of the cigar-chomping General Curtis LeMay as an appropriate model. SAC was notorious for its rigid checklists, strict procedures, and ruthless inspections, a consequence of the complexity of their large bomber aircraft and their crews' awesome responsibility for obliterating half of the earth with atomic weapons at a moment's notice. TAC, with its own increasingly sophisticated weapons and a growing stockpile of tactical nuclear weapons, was implicitly arguing for the same. The fact that the senior general in charge of TAC, General Walter Sweeney Jr., had come from SAC probably fueled the comparison. But nonetheless, for TAC in the mid-1960s, *professional* equaled checklists, procedures, and standards; technology demanded professionals.[112]

In the past, the "buzz boy" fighter pilot was prized for his individuality and his quick and improvisational thinking. The earliest celebrated fighter pilot, France's Roland Garros, was explicitly recognized as an artist; he possessed, in his words, "style."[113] Now, fighter pilots' aerial artistry was to be encoded into fire-control computers and guided missiles and documented in stacks of technical manuals and checklists. Try as the engineers might, they found it exceedingly difficult to commit the tacit knowledge of air-to-air combat to explicit procedure. Moreover, the advanced technologies that were introduced to facilitate this shift ultimately required their own level of tacit knowledge for effective and efficient operation. For example, there was no standard setting for course and fine radar gain for the F-4C's radar. Rather, the pilot's ability to pick out a low-flying target on a rain-filled night in mountainous terrain became a recognized and valued "black art" that could only be learned through experience.[114] When the escalating costs of operating the advanced aircraft and their

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[111] Willetts to SAF-OII, "Information Policy Guidance Input," 1–1. Emphasis added.

[112] *History of the Tactical Air Command, Jul - Dec 1961*, 1:12–13. When Sweeney took command of TAC on September 30, 1961, he already had a reputation as a "tireless worker [and] efficient manager." Described as a "vigorous Commander," some noted of Sweeney, "He'll do for TAC what LeMay did for SAC." On the culture and organization of SAC, see Deaile, "SAC Mentality." On the "SAC-timization" of TAC, see Crane, *American Airpower Strategy in Korea*, 172; Ziemke, "In the Shadow of the Giant"; Hannah, *Striving for Air Superiority*; Michel, "Revolt of the Majors," 43–48.

[113] Wohl, *Passion for Wings*, 203.

[114] Anderegg, interview, October 2, 2013; Sokol, interview.

technologies forced reductions in flight time and training, the fighter pilot community responded not with more procedures, but with new forms of apprenticeship-style instruction. The pilots' demands for new and improved cockpit recording technologies so that they could better critique and coach each other are one manifestation of this apprenticeship-like behavior.[115]

Hence, this conflict in this historical fighter pilot example between the images of *professional* and *craftsman* reveals an interesting feature of human-machine systems. In a complex socio-technical environment, the craftsman-like component is rarely obviated by automated machinery and procedural checklists. Rather than being automated-out by the technology, the operator's artistry more often simply takes a different form as he or she establishes new relationships with his or her machinery in a process of coevolution.[116] Moreover, this historic fighter pilot example also illustrates how a powerful myth of the operator can shape the system's behavior, influencing both the performance of the operators and the machinery designed for their use. Specifically, I argue that in this example of Air Force fighter aviation, although the evolution of tasks was accompanied by rhetoric that emphasized the pilot's increasing use of technology and the explicit procedures needed to operate that advanced technology, it was in fact the retained elements of craftsmanship and individual human artistry and intuition, albeit manifested in different forms as the pilot-operators tinkered with their otherwise codified tactics and procedures, that characterized the modern fighter pilot's tasks. This allowed the pilot to retain and validate his personal connection with the popular, historic fighter pilot myth and affirm his professional identity as a fighter pilot.

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[115] Anderegg, *Sierra Hotel*, chap. 10; Anderegg, interview, October 2, 2013. On apprenticeship-style behavior, see Sennett, *Craftsman*, chap. 6.

[116] It is important to note, though, that the operator, while not being eliminated, may nonetheless change locations, identities, professions, skills, etc. to reflect the new artistry required. It is essentially a process of developing new tacit knowledge to accompany the new equipment, something Sennett suggests is best accomplished with a craftsman-like outlook and the importance it places on iterative "problem solving" and "problem finding" Sennett, *Craftsman*, 11, 26, 48. For another perspective on the problems associated with capturing tacit knowledge and transforming it into procedural knowledge, see Vincenti, *What Engineers Know*, chap. 6. Abbott's definitions of *professional* and *craftsman* differ from Sennett's, but Abbott acknowledged the process by which changing technologies can alter workplace tasks, which can lead to conflicts over "jurisdictional" boundaries between professions. Abbott, *System of Professions*, 92–94. The question still remains, though, what happens when the new skills no longer resemble the old ones from the past?

A Note on Sources

The source materials used during this study reflect the human-and-machine perspective employed in it and its relatively narrow air-to-air fighter pilot scope. Because I focus on the relationships within the fighter pilot's cockpit and those that extended between fighter cockpits once the pilots were assembled into formations, I generally exclude fighter pilots' interactions with other agencies and individuals.[117] The sources used to develop my analysis can be divided into two broad categories: how the system was supposed to function, and how the system was actually used in practice. For both categories, I relied on a variety of primary and secondary source literature.

For example, in the analysis of the F-86 and its A-1C(M) gunsight in Chapter 3, Air Force flight manuals for the F-86 Sabre and related official operations and maintenance handbooks for the A-1C(M) gunsight provided the bulk of technical information regarding the system. Most of this documentation was discovered at the Air Force's Historical Research Agency (AFHRA) and the Muir S. Fairchild Research Information Center (MSFRIC), both at Maxwell Air Force Base (AFB), Alabama. Additional reference materials were located at the archives for the National Museum of the US Air Force (NMUSAF) and the historian's office for Air Material Command, both located at Wright-Patterson AFB, Ohio. The Defense Technical Information Center (DTIC) online document repository likewise provided additional useful technical reports and relevant data. For the A-1 gunsight in particular, the Massachusetts Institute of Technology (MIT) library system and the MIT Museum in Cambridge, Massachusetts, maintained relevant technical reports published by the Instrumentation Laboratory, office correspondence, and an early prototype of the A-1B gunsight computer and its corresponding sight unit.

Unfortunately, in several instances, I lacked the key, single-source document I had once hoped to find. Consequently, I had to extrapolate and triangulate between different source documents that referenced or partially specified the data that I was searching for. For example, the only flight manual for the F-86E that I could find was dated 1956, well after the

[117] This includes the radar operators that helped feed target information to the pilots. While there is a separate rich history on the fighter pilots' relationships with their GCI (ground controlled intercept) and AWACS controllers, it is beyond the scope of this project. See, for example: Archibald, "GCI: Dregs or Non-Flying Wingmen?"; Townsend, "Letters: Taking Issue with GCI Article - Summer 79"; Archibald, "Letters: Taking Issue with the Issue."

1951-52 timeframe that is the primary focus of Chapter 3. However, with access to other primary documents from the period, and possessing first-hand knowledge of how the Air Force publishes and annotates changes to its flight manuals, I felt comfortable extracting the relevant portions of the later flight manual if I determined it was indicative of the information available to the earlier Sabre pilots. In all instances, the footnote and bibliographic information indicate the sources I used.

To develop an understanding of how the system was actually used in combat, I relied on a mixture of primary source literature, including archived mission summaries, which the pilots filed immediately after their combat sorties, and the F-86 units' tactical doctrine manuals, which were written in the field during the conflict. The former provided immediate, first-hand, unembellished accounts of air combat and necessary context. The latter unit tactical doctrine manuals proved especially helpful in understanding why the pilots did what they did. Iteratively produced during the war, these manuals allowed pilots to standardize operations across their units and educate newly arriving pilots on the nuances of combat operations. Although the pilot-written tactical doctrine manuals rarely contradicted the engineer-written technical flight manuals, they often provided a finer-level of detail and granularity, codifying what would otherwise be pilots' tacit knowledge. They represent an authoritative, single source of the combat tactics and equipment procedures thought best at the time. Furthermore, because the tactics manuals were continually revised, they provide an excellent indication of pilots' evolving attitudes and the adaptation process by which they incorporated new technologies and adopted new tactics.

The combat reports and the tactical doctrine manuals, while vital to the analysis, however did not yield a necessary appreciation for the pilots' motivations in air combat. To complete this part of the analysis, I relied on the stories of war and air combat as told by individual pilots. Primary sources for these narratives included pilots' own end-of-tour reports, oral histories, and later memoirs. While these sources are understandably biased, and the veracity of some of their information tended to diminish as the time between combat and reflection grew, they were invaluable in developing an understanding of the pilots' charged and visceral reactions to the experience of life-or-death air combat and the influence of the fighter pilot myth on their attitudes. After reviewing the stories of numerous pilots, and in light of the other research materials I had collected, I attempted to select individual

stories and anecdotes that best captured the broader sentiment that permeated the fighter pilots' experience of combat.

Secondary source literature was used primarily to develop the background history of the broader war and to establish the context for the fighter pilots' involvement in it. These secondary sources included official flying unit histories, which were compiled periodically by the units during the war, official reporting and summaries of the progress of the war, and later scholarly works. I also relied on newspaper and popular magazine articles published during the period as a window into the popular cultural understanding of the fighter pilots and the myth that surrounded them. As noted earlier, while there are numerous volumes of secondary source literature that discuss the specific aircraft systems or specific pilots, rarely do the sources investigate the intersection between the "great machine" and "great pilot" narratives. Nevertheless, these secondary sources provided useful details on specific systems or to augment the pilots' own narratives.

I used similar source material while developing Chapter 4, the discussion of the Phantom in Vietnam. One additional source that proved especially useful was the Air Force fighter pilot's professional journal, *Fighter Weapons Newsletter.* First published in 1951, the journal took a two-year hiatus until the pressure of the Korean War had passed. In 1971, it was retitled *Fighter Weapons Review.* The journal's articles are generally short, written by fighter pilots for fighter pilots, and concentrate primarily on discussions of emerging fighter tactics and best practices. Since the journal was published at Nellis AFB, Nevada, the small community of fighter pilots there exerted considerable influence over its contents. Hence, at times, the opinions expressed in the journal do not adequately reflect those of the broader Air Force fighter pilot population, and occasionally controversy spilled over onto the journal's pages. The articles detailing these controversies, particularly over the "fighting wing" formation, provide an excellent window into the process of fighter tactics development and the evolution of fighter pilots' attitudes regarding their tactics and their equipment. Also of note, I was able to conduct in-person interviews with several Vietnam-era combat pilots to augment the collection of oral histories already on file at the Air Force's archives.

The discussion of the F-15 Eagle in Chapter 5 presented documentation challenges. Hoping to avoid classification issues, I elected to terminate this study with the F-15A, knowing that the F-15C version that was used in Desert Storm is still in use today and

therefore subject to extensive classification. While I was able to gain access to primary documentation such as F-15A flight manuals and the training syllabi used to train new F-15 pilots in the mid-1970s, I lacked a comparable level of primary source documents that I had enjoyed when drafting the earlier F-86 and F-4C case studies. Moreover, because the USAF's F-15A was not used in an active shooting war during this period, I had to rely on evaluations of simulated air combat, notably the AIMVAL-ACEVAL tests conducted in 1977. Surprisingly, those test reports remain classified some thirty-five-years later, which also contributed to a dearth of scholarly secondary source literature available regarding the two tests. Working with declassification authorities at the Air Force's archives, I was able to extract enough relevant, unclassified information to complete my analysis. I was also able to make contact with three of the eight F-15 pilots that flew in the tests, two of the primary data analysts, and the director of operations at TAC that helped oversee the tests. Their personal perspectives helped illuminate the gaps in the available written documentation.

Collectively, these sources allowed me to explore how new fire control system technologies, which were introduced to make the pilots more lethal and increase their effectiveness, also challenged the historic experience of being a fighter pilot. In each case, there is a divergence between how the technologies were supposed to function and how pilots actually used them in air combat. The consequent effects of this divergence on the individual pilot using the equipment, and the attempts by the fighter pilot community-at-large to preserve their place in the cherished myth of the fighter pilot, comprises the prime analytical component of each pilot-aircraft case.

But before we can begin to look at the Sabre pilot's experience in Korea, we need to first understand and appreciate the myth of the fighter pilot that emerged in the cauldron of the Great War. The myth's portrayal of the relationship between a fighter pilot and his technology would exert a powerful influence over all successive generations of American fighter pilots. It was this myth that became timeless, not the pilots or their skill sets. Addressing the origins and purposes of this myth is the subject of the next chapter.

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Chapter 2

The Myth of the Fighter Pilot

> *The word flying has always been synonymous with fighting, first against prejudice, then against wind, weather, and the malice of inanimate matter, then for the laurels of records of height, speed and duration and finally against a host of enemies in the air.*
>
> —*Pursuit Text*, Army Air Corps Training Regulation 29-229, 1929

In 1955, Major Frederick "Boots" Blesse was commander of the 3569th Combat Crew Training Squadron. Based out of Nellis AFB, the self-declared "Home of the Fighter Pilot" and located about 15 miles northeast of Las Vegas, Nevada, Blesse's squadron took newly winged pilots fresh from training and in a few weeks transformed them into *fighter* pilots. With the Air Force in the process of tripling in size, the pace was hectic and characterized by "tightly compacted training and extremely heavy flying schedules." Blesse had to educate the young pilots on the more advanced systems installed in the Air Force's front-line fighters, train them how to fly the faster and more maneuverable machines in simulated air combat, and show them how to use the aircraft's weapons to hit a slew of practice targets. Despite the pressure, Blesse excelled, both as a unit commander and as an individual fighter pilot.[1] That year, he took first place in all of the individual events at the USAF Worldwide Gunnery Meet, an unprecedented and never repeated feat.[2] He also authored what became the definitive tactics manual for jet combat. For its title, Blesse

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[1] Blesse, *Check Six*, 89–92. Blesse's commanding officer, Colonel Bruce Hinton, the commander of the first Sabre unit deployed to the Korean War and a jet ace himself, described Blesse as "an alert, creative mind … who did almost everything well."

[2] "Major General Frederick C. Blesse."

selected the mantra he coined while battling MiGs in his F-86 Sabre en route to becoming one of America's top-scoring aces of Korea: "No Guts, No Glory."[3]

Blesse was born on August 22, 1921. The only son of a successful Army doctor, he earned his "Boots" moniker for stomping around the house in the polished shoes his father wore with his uniform. When he was nine and his family stationed at Fort Leavenworth, Kansas, the young Blesse befriended a neighbor Army Air Corps pilot and spent "quite a bit" of time talking to him about "pursuit planes." Blesse applied to West Point several times before he was finally accepted and ordered to report to the campus on July 1, 1942. He was elated. In his memoir, he remarked that his standard prayer as a teenager was, "Please God, let me go to West Point and let me become a great fighter pilot." Now he was finally on his way to fulfilling his "lifelong ambition." As he later acknowledged:

> I had dreams of becoming an ace as long as I could remember.... I grew up reading *G-8 and his Battle Aces* and *Tailspin Tommy* in the funny papers, dreaming of the fighter pilot's life. "Captain Eddie" [Rickenbacker] was my hero, now joined by World War II aces like Gabreski, Mahurin, Bong, McGuire, Thyng, and others. The picture was always in the back of my mind—fighter pilots diving, climbing, turning, finally destroying the enemy aircraft; bringing honor and glory to themselves and their country.[4]

Blesse's attachment to the legendary aces of old and the classic imagery of air combat was not unique to him. Robin Olds, an ace from World War II who would achieve renown as a fighter pilot and wing commander during Vietnam, remembered meeting Eddie Rickenbacker as a child but being "too awed to say anything."[5] Rickenbacker, the American Ace of Aces in World War I, was also "hero" to Walker "Bud" Mahurin, one of Blesse's influential aces from the Second World War.[6] Too young to have a personal attachment to the Great War aviators, Mike McCarthy, a Phantom pilot in Vietnam, revered "the fighter pilots of the Battle of Britain—the legendary 'Few.'"[7] Thus, most fighter pilots, whether walking out to a P-51 during World War II, an F-86 in Korea, or an F-4 in Vietnam, carried

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[3] Blesse, "No Guts, No Glory"; Blesse, *Check Six*, 57.

[4] Blesse, *Check Six*, 3–5, 11, 56.

[5] Olds, *Fighter Pilot*, 5–6. Olds's father, Robert, was a pioneer in early American military aviation; he served as aide to General William "Billy" Mitchell and later became director of the Air Corps Tactical School. Hence, for Robin, "The pulp-fiction heroes of *G-8 and His Battle Aces* were also the real men that moved through my daily life."

[6] Mahurin, *Honest John*, 18.

[7] McCarthy, *Phantom Reflections*, 7.

within them a powerful personal attachment to the past warrior-aces, imagining themselves as members of the privileged "few" who had the opportunity to climb into an airplane to battle "wind, weather, and the malice of inanimate matter … against a host of enemies in the air," hoping like Blesse to capture "honor and glory" for "themselves and their country."[8]

The powerful rhetoric and the captivating imagery associated with the earliest military aviators were, however, elements of a myth. Myths often carry connotations of elaborately constructed falsities designed to entice individuals and elicit specific, desired responses. This does not reflect my use of the *myth* term, though. As Roland Barthes's study of myths and mythology demonstrated, today's pejorative conceptions are usually unwarranted. Myths are "a language" or "a type of speech." They are not defined by their type of message or even their intended purpose, but rather only by their construction. In a myth, an object with understood significance is presented, but in an abstract or purposefully incomplete manner that implicitly separates the object from its detailed historical "richness." For Barthes, "it is this constant game of hide-and-seek between the meaning and the form [or message] which defines myth." It "is neither a lie nor a confession: it is an inflexion" that "transforms history" into something that instead seems natural.[9]

While others, notably Robert Wohl and Peter Fritzsche, have already investigated the public and private purposes of the fighter pilot myth as it emerged in World War I (albeit without using the *myth* label), in this chapter I am specifically interested in the inconsistencies that arose between the myth and the pilots' actual experience of air combat.[10] Invoking Barthes's definition, the fighter pilot myth was not an outright lie but a purposeful opaquing of historical events. It consisted of three interrelated messages: 1) that air warfare represented honorable combat fought by honorable individual warriors; 2) that it was the unique flying skill of the pilot that dictated success; and 3) that the tallies of aerial victories recorded by the pilot, reported in newspapers, and which were eventually inscribed on the sides of his aircraft, provided an appropriate measure of his success. During the interwar

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[8] *Pursuit Text*, 17; Blesse, *Check Six*, 56.

[9] Barthes, *Mythologies*, 11, 109, 117–18, 129, 151. See also Campbell, *Hero with a Thousand Faces*; Campbell and Moyers, *Power of Myth*.

[10] Wohl, *Passion for Wings*, chap. 7; Fritzsche, *Nation of Fliers*, chap. 2. See also Morrow, *Great War in the Air*, xiv–xv. Morrow noted that the "concentration on the 'knights of the air' stems from a natural tendency to emphasize the heroic.... The fighter pilots consequently became not only the symbols of aviation but also the ultimate heroes of World War I."

years and through World War II, the myth was further ritualized as the US Army Air Corps studied and formalized its processes for selecting and training its fighter pilots. Hence, when future pilots took to the skies over Korea, Vietnam, and Nellis, it was the myth of the fighter pilot that provided the basis for their expectations, not necessarily the actual earlier experiences of air warfare. Stripped of its historical "richness" and "contingency," the myth of the fighter pilot remained remarkably consistent across these various experiences and in spite of ever-changing technologies, thereby setting the stage for the distortions and misconceptions of air combat and the human-machine interactions therein that continue to plague military aviation today.

Crafting the Mythical Ace

Despite the timeless significance it would eventually assume, the "ace" distinction had surprisingly inauspicious origins. The term was first associated with a skilled pilot when a Paris newspaper in 1915 declared the recently felled Adolphe Pégoud "*l'as de notre aviation*" (the ace of our aviation). Credited with downing six enemy aircraft before his death, two-years earlier Pégoud was wowing crowds of two hundred thousand with his masterful displays of aerobatics.[11] After its initial appearance in print, the *ace* appellation quickly cemented itself into the French lexicon. Shortly thereafter, the French Air Service decided to regulate its usage, reserving the distinction for those pilots that had scored five victories over enemy aircraft. The other warring nations soon followed suit.[12]

It is perhaps fitting that the *ace* term was manufactured by neither the military nor the pilots, but by literary publicists. As Pégoud's earlier aerial exhibitions revealed, aviation already solicited an enthusiastic popular response prior to the Great War, especially within France. But as Wohl argued, it was the propagandizing efforts of the belligerents' national

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[11] Pisano et al., *Legend, Memory, and the Great War*, 35; Wohl, *Passion for Wings*, 203, 304n2; Crouch, *Wings*, 121, 157.

[12] Pisano et al., *Legend, Memory, and the Great War*, 35–36; Wohl, *Passion for Wings*, 304n2; Fritzsche, *Nation of Fliers*, 74; Crouch, *Wings*, 157; Gurney, *Five Down and Glory*, 15. There was no logical precedent for the initial five-victory requirement. Pisano et al. note that Pégoud was bestowed with the honor of "*l'as*" after his fourth victory; they likewise claim that Immelmann had only four victories when he became "the first German pilot to be designated with this [ace] honor." There is some discrepancy, however; see, for example, Crouch and Fritzsche. Furthermore, the five victory requirement was not static during the war. Wohl noted that as the number of aircraft in the skies over the Western front multiplied, the French Air Service upped the requirement in 1917 to ten victories. There were plans to increase the requirement once more in 1918 to twenty victories but war's end intervened.

media that played an "indispensable role" in transforming skilled aviator-showmen like Pégoud into the war's mythical aviator-aces.[13] Fritzsche likewise showed how the "image of the war ace" and his exploits bore little resemblance to the reality of air combat in the latter half of the First World War.[14] In the hands of skilled publicists, the aces were custom-crafted to fulfill desperate demands for worthy and inspiring national heroes. As Europe watched her sons being consumed in the trenches by the technology once-considered "the surest proof of their civilization's superiority," the tales of gallant aces who seemed to abide by the time-honored principles of "honor, duty, effort, courage" provided a powerful antidote.[15]

Pégoud may have been the first anointed with the title "*l'as*," but it was another French aviator's ingenuity that would establish the enduring image of the solitary, self-reliant, self-sufficient ace-pilot perched in his small craft. Roland Garros, like Pégoud, was a sportsman-aviator prior to the Great War. When war erupted, Garros too enlisted in the French Air Service, but he quickly grew dissatisfied. Flying a two-seater reconnaissance aircraft, it was not Garros but his observer who was responsible for shooting down enemy aircraft, and his observer wasn't hitting anything. Following one unsuccessful mission, Garros griped, "Our armament has shown itself to be insufficient." Thereafter, Garros, with the help of his mechanic Jules Hue, elected to get rid of his human baggage and instead mount a Hotchkiss machine gun directly in front of his seat, aligned with the aircraft fuselage. To avoid shooting off his own propeller, Garros and Hue attached a set of steel deflectors to the blades. Garros took his new contraption to the Front in mid-March 1915, and within three weeks beginning April 1, he had downed three German aircraft.[16] When news of Garros's accomplishments leaked to the French press, the nation exploded in

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[13] Wohl, *Passion for Wings*, 243. See also Wohl's earlier chapters on the European enthusiasm for aviation prior to the Great War.

[14] Fritzsche, *Nation of Fliers*, chap. 2. Fritzsche primarily focused on the German experience; on the English experience, see Hart, *Aces Falling*.

[15] Adas, *Machines as the Measure of Men*, 368–69; Fritzsche, *Nation of Fliers*, 3, 82; Pisano et al., *Legend, Memory, and the Great War*, 29. Fritzsche contends, "If machines were the measure of men in the modern era, as Michael Adas argues, airplanes and airships were the measure of nations at the beginning of the twentieth century." It is therefore a logical extension that the pilots that flew the airplanes and airships would be seen as measures of the virtues of the citizenry.

[16] Wohl, *Passion for Wings*, 203–8; Morrow, *Great War in the Air*, 91–92; Crouch, *Wings*, 157. Garros's invention quickly populated the service. Pégoud described the experience of shooting his machine gun at the specially equipped propeller, "About every sixth shot hits the propeller and bounces back at me. Often I hear it whistle past my ear. Sometimes I fear I am more apt to shoot myself down than I am to shoot down my intended victim."

adulation. *L'Illustration* proclaimed, "He piloted the plane he himself created, a Morane monoplane, ingeniously, lovingly adapted and perfected by him, a light and beautiful machine, similar to a lark, delicate and tiny in comparison to the hawk it had to attack, but formidably armed with a machine-gun. And Roland Garros mounted alone this machine, his child."[17]

As Garros's innovation spread, fighter pilots welcomed the new single seat aircraft and its promise of unprecedented aerial autonomy.[18] No longer would a pilot have to weigh down his "lark" with another body; now he could rise up into the sky and snatch glory for himself. "I believe in the saying that 'the strong man is mightiest alone,'" Oswald Boelcke exuberantly wrote his parents on July 10, 1915, after learning he would begin flying the new single-seat Fokker E. "I have attained my ideal with this single-seater; now I can be pilot, observer and fighter all in one." A few days later, Boelcke was still gushing: "My little single-seater possesses the advantage of giving me complete independence; I can fly when, where, how long and how I will."[19]

Unlike the masses slated for slaughter in failed assaults on opposing trenches, individualism became the hallmark of the aviators' conquests in the skies. Their aerial triumphs were readily quantifiable, individually assignable, and, with some artistic license, always captivating. The pilots' own serialized descriptions of their battles stoked the image of aerial combat as a "game—an amazing game," in the words of one French aviator. "A game of adventure, of countless thrills, of soul-stirring excitement, a game in which courage, daring, resource, determination, skill, and intelligence achieve honor in life, or if the fates so decree, glory in death."[20] German ace Ernst Udet remembered fondly of an engagement in which he and his foe paused long enough to wave at each other, "Suddenly, I had the

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[17] Quoted in Wohl, *Passion for Wings*, 210.

[18] During the war, the Americans used the term "pursuit" for their aircraft designed and equipped "primarily to destroy hostile aircraft in flight." The French referred to theirs as "*avions de chasse*." Hence, World War I fighter pilots were sometimes referred to as pursuit pilots or *chasseurs*. *Pursuit Text*, 3. For consistency, I simply refer to these individuals as fighter pilots and their aircraft as fighters.

[19] Quoted in Werner, *Knight of Germany*, 114–15, 126–27, 135; Wohl, *Passion for Wings*, 207–8, 214. The Germans discovered Garros's innovation when he was forced down behind enemy lines in April 1915. Within months, the Dutch designer Anthony Fokker had developed a mechanical interrupter gear that synchronized the machine gun's firing with the spinning propeller. When paired with a small but fast eighty-horsepower monoplane, the Fokker E, the new armament system helped inaugurate a nearly six-month period of unmatched German air superiority, bemoaned behind Allied lines as the "Fokker Scourge."

[20] Quoted in Wohl, *Passion for Wings*, 226, 239, 244–45. Richthofen in his memoirs likened the thrill of air combat to that of hunting big game.

strange feeling that I wasn't confronting an opponent but practicing turns with a comrade."[21] Additional tales of squadrons on both sides of the Front raising glasses and dropping wreaths to honor fallen foes contributed to the notion that, despite the barbarity transpiring on the ground, "an honorable war among men" was being fought in the sky. Aerial combat was, in the words of German flyer Erwin Böhme, a contest that pitted "man against man, with equal weapons and equal chances."[22]

Soon the names of the young lieutenant flyers began appearing besides, if not above, those of the great generals.[23] In France, in addition to Garros, Georges Guynemer became a prime beneficiary of the journalists' exaltations. Despite being born into a "comfortable, country-squire life" and destined for studies at the prestigious *Ecole Polytéchnique*, the young nineteen-year-old Guynemer tried on several occasions to enlist in the French army, but each time he was turned away due to his "feeble constitution." Through dogged persistence, and perhaps some help from his influential father, Guynemer eventually secured an opportunity to begin flight training. Even then, he was initially ridiculed as "*un petit jeune homme*" and a "*filette*." Once turned loose over the Front, however, Guynemer earned a reputation as a fearless aviator, often flying several missions each day and typically scoring his victories from near-point-blank range. He was lauded as "a model of dedication and courage."[24] When Guynemer mysteriously disappeared during a mission in September 1917—heavy artillery barrages in the area delayed discovery of the fallen pilot and his wrecked plane for several weeks—French journalists constructed a tale in which Guynemer was plucked from his aircraft by angels. "*The ace of aces* one day flew so high in combat that he never came back to earth," wrote one in *L'Illustration*.[25]

Across the lines in Germany, newspapers eagerly kept tally as Boelcke and Immelmann jockeyed for position as their nation's leading scorer, and the country's High

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[21] Quoted in Fritzsche, *Nation of Fliers*, 87–88.

[22] Ibid., 87–89; Driggs, "Aces Among Aces," 574; Wohl, *Passion for Wings*, 250. Böhme also wrote that he "looked forward to 'fencing' with a 'fair Englishman.'" It is ironic that within two weeks of penning his letters, Böhme would inadvertently bring down Boelcke in a disastrous mid-air collision—apparently it wasn't always "equal weapons and equal chances."

[23] Pisano et al., *Legend, Memory, and the Great War*, 31. Pisano et al. were quick to point out, however, that the "ace's combat role was not as vital as that of the 'mighty Generals behind the lines.'"

[24] Quoted in Wohl, *Passion for Wings*, 229–33.

[25] Quoted in Ibid., 233–36. Guynemer's name was subsequently inscribed in the Panthéon as a "symbol of the aspirations and enthusiasms of the Nation."

Command began recounting the aces' individual victories in their wartime communiques. Showered with honors and decorations, the two early aviators were portrayed in the media as "idealists, pure in soul and body, fearless and disciplined," each ready to "sacrifice his life willingly, gladly, even lightheartedly to the cause of the *Vaterland*."[26] When Richthofen rose to replace the two fallen aviators, he too was molded to reflect national virtue, transformed by the state's publicists into a model, humble servant.[27]

Britain and America were initially more circumspect in their adulation of their ace flyers. According to Peter Hart, the British "preferred to maintain the illusion" that its combatants "were all part of a team with no 'star turns.'"[28] The Americans harbored a similar sentiment, made explicit in a circular distributed after the war: "The US Air Service does not use the title 'Ace'.... It is not the policy of the Air Service to glorify one particular branch of aeronautics, aviation, or aerostation at the expense of another."[29] But, try as the two services might, there was no avoiding the ace frenzy. Captain Albert Ball, Britain's leading flyer at the time, was mauled by the press when he returned to England in October 1916. Declared by his town's mayor to be "the greatest living expert in aerial warfare," Ball was reportedly a model of modesty at the ceremony; "conceit was not in his nature," Ball's biographers noted in their 1918 text.[30]

For the Americans, it was Captain Eddie Rickenbacker who stole the nation's attention. A rabble-rousing youth from Columbus, Ohio, Rickenbacker from an early age exhibited an uncanny ability to court and then skirt death. When he was eight, he along with the other members of the local Horsehead Gang went to the nearby gravel mine to race steel

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[26] Ibid., 215–16, 221–22. Boelcke's meteoric success and tragic fall likewise became a powerful testament to Germany's indomitable spirit: "Up to his death he was unconquered. Now he is not only someone who was great, now he will remain great forever."

[27] Hart, *Aces Falling*, 48; Kilduff, *Richthofen*, 107, 198; Wohl, *Passion for Wings*, 225–28. Richthofen's wartime memoir, *Der rote Kampfflieger*, was carefully crafted to achieve maximum morale-boosting effect. In it, he wrote: "I should consider myself a despicable creature if, now that I am loaded with fame and decorations, I should consent to live on as the pensioner of my own dignity and to preserve my valuable life for the nation, while every poor fellow in the trenches, who is doing his duty just as much as I am, has to stick it out." The Red Baron's humility is also made apparent in another passage: "I am no record keeper, [and] in general, records are far from our thoughts in the flying service. One only fulfills one's duty."

[28] Hart, *Aces Falling*, 2.

[29] "Enemy Aircraft Destroyed by US Army Air Service." The circular continued: "The work of observation and bombardment is considered equally as hazardous as that of Pursuit, but due to the fact that the Observation and Bombardment pilots are not called upon merely to destroy enemy aircraft, it should not be allowed to aid in establishing a popular comparison of results merely by relative victories."

[30] Briscoe and Stannard, *Captain Ball*, 220–21, 291; Hart, *Aces Falling*, 2, 48.

mine cars down the slope. The car tipped and Rickenbacker was nearly crushed, his leg sliced open to the bone. Following his father's untimely death a few years later, Rickenbacker was forced to temper his reckless behavior with honest work. After a smattering of odd jobs, he became a skilled automobile mechanic, but his thirst for adventure never disappeared. Within a few years, he was racing at Daytona and in the Indianapolis 500.[31]

When America entered the war in 1917, Rickenbacker had already fallen victim to the captivating ace narrative and hatched a plan to recruit several of his fellow racecar drivers "for aviation work." As he would later comment, "The excitement of automobile racing did not compare with what I knew must come with aeroplane fighting in France." Technically too old to become a pilot—he was then twenty-seven—Rickenbacker set sail with the American doughboys in May 1917 destined to be a chauffeur for General "Black Jack" Pershing. Later assigned to drive for the American airpower advocate General William "Billy" Mitchell, Rickenbacker eventually scored his coveted aviation assignment. In March 1918, he was assigned to the newly formed 94th Hat-in-the-Ring Squadron under the leadership of Major Raoul Lufbery. Rickenbacker would go on to succeed Lufbery as commander of the 94th and eventually became America's Ace of Aces with twenty-six victories.[32]

In his immediate post-war memoir, *Fighting the Flying Circus*, ghost-written by aviation enthusiast Laurence La Tourette Driggs, Rickenbacker's sense of derring-do was paired with a strong devotion to the principle of "fair play" and a keen sense of responsibility for his men's well-being, honorable traits appropriately reflective of American ideals. In the book, for example, Rickenbacker boasts of his resolution to "never shoot at a Hun who is at a disadvantage, regardless of what he would do if he were in my position." Moreover, Rickenbacker asserted that, "with American flyers the war has always been more or less a sporting proposition and the desire for fair play."[33] Driggs's "Foreword" to the text called further attention to the ace's "feeling of responsibility that every true leader must know. He

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[31] Lewis, *Eddie Rickenbacker*, 1, 13–20, 56–58, 80–86; Glines, "Charmed Life of Captain Eddie Rickenbacker"; Mass, "Eddie Rickenbacker"; Driggs, "Foreword," v. Driggs claimed that Rickenbacker was "the idol of the automobile racing world at the moment when America entered the war."

[32] Lewis, *Eddie Rickenbacker*, 96–98, 102–104, 115–19, ; Wohl, *Passion for Wings*, 240; Driggs, "Foreword"; Rickenbacker, *Fighting the Flying Circus*, 1–2.

[33] Rickenbacker, *Fighting the Flying Circus*, 338–39. Rickenbacker claimed, "I do not recall a single violation of this principle by any American aviator that I should care to call my friend."

is frankly scared over the additional risks that leadership must force upon him. Yet he carries on, assuming these additional risks, which in truth not only limit his private successes but constantly threaten to sacrifice his life for a companion."[34] These were powerful lessons for the American republic and her citizens, and Rickenbacker's book was hailed as "an inspiration to red-blooded Americans." It was also snatched up by "aficionados of aerial warfare" who took Driggs's embellishments of the ace's carefully crafted stories of air combat as "gospel."[35] The fact that Rickenbacker was one of the only great aces to survive combat, thereby granting him the unique opportunity to continue accumulating accolades and successes post-War, contributed to his enduring magnetism in American culture.[36]

The iconic fighter pilot that emerged from the Great War and that would come to dominate future American fighter pilots' image combined elements from each of these legendary aces: Garros's ingenuity and the status afforded to self-reliant, single-seat fighter pilots; despite his timid appearance, the dogged persistence and fierce tenacity of Guynemer; the sportsman heritage and selflessness of the Germans Immelmann, Boelcke, and Richthofen; Ball's modesty; and Rickenbacker's daring adventurism paired with a sense of teamwork and "fair play." In the hands of the publicists that celebrated the flyers' victories and shrouded their defeats in mystery, the aces were transformed into an honorable "brotherhood of knights" that exerted an "irresistible" influence over those in the trenches and on the home front. The mere sight of an ace's aircraft was said to produce among the soldiers "a magnificent surge of enthusiasm," while at home, the aces' "adventures thrill the bosoms of countless thousands."[37] There was simply something captivating about "the dizzy height, the deadly plunge into space, and the plain simplicity of plane against plane, of aerial squadron against aerial squadron."[38] In an age of mechanistic warfare, in which the

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[34] Driggs, "Foreword," vi–vii.

[35] Lewis, *Eddie Rickenbacker*, 213–14, 228, 234–35. Rickenbacker would continue to exercise careful control over the tales of his aerial battles. See, for example, the account of one of his battles in Gurney, *Five Down and Glory*, 53–55. For descriptions of the same battle in the other sources, see: Rickenbacker, *Fighting the Flying Circus*, 113–16; Lewis, *Eddie Rickenbacker*, 154, 163–64.

[36] Driggs, "Foreword," vii. Driggs makes explicit mention of Rickenbacker's good sense to avoid getting killed during the war, "saving himself for the continued service of his country." On Rickenbacker's later life, which included stints as the owner of the Indianapolis 500, general manager of Eastern Airlines, and nearly three-weeks spent bobbing in a raft in the middle of shark-infested South Pacific waters during World War II, see Lewis, *Eddie Rickenbacker*.

[37] Wohl, *Passion for Wings*, 239, 245, 249; "Gallant Feats in the Blue," 58.

[38] Quoted in Wohl, *Passion for Wings*, 244.

machinery of war was relentlessly consuming the individual, the ace flyers were hailed as living proof that man could indeed reassert control over of his machinery and achieve glory and honor in the process.[39]

Revisiting the History

The myth of the fighter pilot proved inspiring, but as Barthes observed of mythologies, it purposefully stripped away much of the historical richness in favor of its message. The pilots of the First World War recognized this. Guynemer divulged the inconsistency in a letter to his father, penned while the ace lay recuperating from a recent wounding in battle, "I've read while in bed that the crowd gave me an ovation in Paris. It's a result of ubiquity. Modern science really does wonderful things, the journalists also."[40] Despite what the popular narrative claimed, aerial combat was no mere "sport" and it was rarely conducted according to some honorable, agreed-upon aviator code. Moreover, the aces' tallies that the newspapers regularly fawned over were not appropriate measures of individual pilot skill: new formation tactics, advancements in aircraft technology, and the inherent inaccuracy in the pilots' reporting of aerial combat all misrepresented the individual ace-flyer's significance.

An Unfair and Deadly Game

Each pilot knew that despite what was said about Guynemer, there was no angel ready to pluck them from a tumbling aircraft or spare them from being consumed in a fiery inferno. Although not living in the trenches, the pilots' lives were infused with macabre reminders of ever-present danger and death. For the average British fighter pilot, life expectancy on the Western Front ran about ten weeks.[41] Thus, despite the popular narratives, the pilots were keenly aware that theirs was likely a brief life in which skill alone would not ensure survival; chance played a large role too.[42] The pilots were haunted not only

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[39] Fritzsche, *Nation of Fliers*, 73. Morrow suggests that the flyers' control over their aircraft offered a new symbol of "technocratic heroism." Morrow, *Great War in the Air*, 26.

[40] Quoted in Wohl, *Passion for Wings*, 232.

[41] Hart, *Aces Falling*, 21, 159, 222–23; Crouch, *Wings*, 166. British aviator Cecil Lewis had a more pessimistic estimation of the "average life span of a British pilot in France in the summer of 1916"—three weeks.

[42] Hart, *Aces Falling*, 4. For Hart, the pilots' despondence can be seen in their photographs: "An aura of doomed youth still clings strongly to the images that have survived of many of the aces. Looking at their photographs the natural effects of overwhelming tiredness and stress are transmuted in our imagination into

by the prospect of having their wings clipped by some lurking enemy fighter plane, but also by the rash of accidents, mechanical failures, and ground-fire that likewise extracted a terrible toll. For example, Britain's leading ace, Captain James McCudden, took off on the morning of July 9, 1918, in his brand-new SE5a, circled the aerodrome, and then proceeded to plummet nose first into the ground from 200 feet, the victim of an apparently faulty carburetor. The ground crews and off-duty pilots that ran to the wreckage were greeted with a typically grotesque scene: the ace's shattered body lay crumpled on the ground next to a broken wing; at least he hadn't burned to death, the onlookers told themselves.[43] Less than a month later, another of Britain's top scorers, Captain Edward "Mick" Mannock, was downed by bullets from a German machine gun post, crashing to the ground "in a burst of flame."[44] The fact that legendary pilots like McCudden or Mannock could be felled not in aerial combat but through hidden flaws in their aircraft or lucky fools firing up from the ground had a disquieting effect on all pilots. Even the great Richthofen became increasingly distraught as he witnessed more and more of his friends succumb to the enemy and to chance.[45]

Moreover, if aerial combat was a sport, it was most definitely a human blood sport characterized not by munificence but by ruthlessness. In the words of Cecil Lewis, a British pilot during the war, "The Angel of Death is less callous, aloof, and implacable than a fighting pilot when he dives."[46] Udet may have fondly remembered exchanging waves with a foe during battle, but such "displays of charity," Fritzsche wrote, "were exceedingly rare."[47] Even Rickenbacker, America's champion of fair play, later acceded, "Fighting in the air is not a sport, it is scientific murder."[48] The goal was to down enemy airplanes, and it didn't matter what type of craft nor the skill level of the opposing pilot. In this "survival of the

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the 'thousand-yard stare' of legend.... Even the greatest of aces was as grist to the all-consuming mill ... that was the Western Front in 1918."

[43] Ibid., 197–99. Burning to death was a prime concern of the early pilots. See discussions in Rickenbacker, *Fighting the Flying Circus*, 95–97.

[44] Hart, *Aces Falling*, 200–204. A few weeks before his death, Mannock wrote a friend, "Things are getting a bit intense just lately and I don't know how long my nerves will last out. I'm rather old now, as airmen go, for air fighting. Still, one hopes for the best."

[45] Kilduff, *Richthofen*, 174; Wohl, *Passion for Wings*, 228.

[46] Quoted in Wohl, *Passion for Wings*, 240.

[47] Fritzsche, *Nation of Fliers*, 90.

[48] Quoted in Lewis, *Eddie Rickenbacker*, 142; Fritzsche, *Nation of Fliers*, 93.

fittest" contest, the most prolific aces preyed on lumbering aircraft piloted by the distracted and the inexperienced.[49]

Pilots soon learned that the best results were obtained when they successfully snuck-up on the unsuspecting pilot and unleased machine gun fury from close-range. Boelcke famously explained his success to his young protégé, Richthofen: "I fly close to my man, aim well, and then, of course, down he falls."[50] A June 1917 account of air combat by French ace Albert Deullin explained that "all the most successful French and English Pilots" preferred attacking "at under one hundred and fifty feet." Explaining how to get to that close position, Deullin in a later report called attention to the single-seater's unique ability to "play tricks, hide himself more easily in the sun, the mist or the clouds, and take advantage of the blind spots of his opponent to carry out crushing attacks."[51] Rickenbacker even shut down his own engine on one occasion to avoid alerting his prey as he dove down before "pulling both triggers for a long burst. [The enemy pilot] made a sudden attempt to pull away, but my bullets were already ripping through his fusilage [*sic*]."[52] Pilots on both sides of the lines quickly learned the value of the adage, "attack ahead while looking to the rear."[53]

The fighter pilot narrative also tended to cast the pilots' victories as the destruction of hostile aircraft, not necessarily the killing of enemy pilots.[54] Some pilots subscribed to the alluring rhetoric, at least momentarily. For example, one British aviator considered the "German pilot and his aeroplane" an "impersonal thing to be destroyed before it destroyed

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[49] *Pursuit Text*, 24–25. The 1929 text noted that in the Great War, "it was extremely rare that the great aces met each other in combat. The novices in fighting airplanes frequently fell easy victims to the greater experience of the famous fighting pilots. It was the world old game of survival of the fittest." Of Richthofen's eighty confirmed victories, less than half were scored against similarly equipped single-seat fighters.

[50] Quoted in Fritzsche, *Nation of Fliers*, 90–91; Hart, *Aces Falling*, 45; Kilduff, *Richthofen*, 238. Maneuvering to achieve surprise and "attack[ing] when the enemy least expects it or when he is pre-occupied" were fundamental precepts of Boelcke's *Dicta*, included in Franks, "Introduction," 5.

[51] Deullin, "Pursuit Work in a Single Seater," 2–3; Deullin, "Chasseur Patrols," 1. Translated copies of Deullin's reports made their way to the Americans, although the French ace's name in the copies was misstated as "Albert B. Deuillin S.73 [Spad *Escadrille*.73]."

[52] Rickenbacker, *Fighting the Flying Circus*, 262–63.

[53] Deullin, "Pursuit Work in a Single Seater," 1; *Air Service Pursuit and Combat Manual*, 2. Richthofen likewise warned his pilots, "The greatest danger for a single-seater is the surprise attack from behind." Kilduff, *Richthofen*, 237.

[54] Wohl, *Passion for Wings*, 240; Fritzsche, *Nation of Fliers*, 88.

you.... I did not continue to think of the enemy pilot as a man."[55] Boelcke, trying to allay his mother's fears that he was becoming too calloused in his reports from the Front, assured her in a letter dated September 16, 1917: "We have nothing against the individual [pilot]; we only fight to prevent him flying against us." That was why, Boelcke reasoned, "it only counts as one victory when two inmates are killed."[56]

As Boelcke's stated rationale admitted, the unnatural distinction separating destruction of the machine from the death of its occupants was less opaque than often acknowledged. For example, Mannock earned the admiration of the young pilots in 85 Squadron because "He wasn't interested in just killing [the Huns] himself. He wanted a lot of them killed, and he trained us how to do it."[57] Despite his extolling his fellow Americans' respect for the principle of "fair play" in air combat, Rickenbacker offered a gushing description of his friend Lieutenant Doug Campbell's fifth victory in May 1918: "Lieutenant Campbell first tried a diving attack, from above and behind.... He had an excellent chance of killing the observer with the first burst ... but no such easy victory awaited him." The battle continued for 15-minutes before Campbell

> saw a curious sight. The observer was standing proudly upright and his arms were folded! From the edge of his cockpit the empty ammunition belt floated overboard and flapped in the wind. He had indeed exhausted his ammunition and now stood awaiting his doom.... As Doug said later, he was so impressed with the bravery of the action that he felt he could not continue the combat against an unarmed enemy....
>
> Upon second thought Lieutenant Campbell realized this was not a game in which he was engaged. It was war.[58]

Campbell proceeded to shoot the enemy crew out of the sky. They were both killed, and "Douglas Campbell that night received the heartiest congratulations from all the boys in the squadron as the first American ace."[59] Thus, while the opposing pilots may have shared a

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[55] Quoted in Hart, *Aces Falling*, 159; Wohl, *Passion for Wings*, 306n106. McCudden recalled being surprised when "at times when I have passed quite close to a Hun machine and have had a good look at the occupant ... 'By Jove! there is a man in it.'"

[56] Quoted in Werner, *Knight of Germany*, 240–41.

[57] Quoted in Hart, *Aces Falling*, 202.

[58] Rickenbacker, *Fighting the Flying Circus*, 122–26.

[59] Ibid., 126. Rickenbacker's approval of Campbell's tactics, and indeed his satisfaction with his own surprise attacks, is particularly intriguing in light his assertion (cited earlier) that he would never attack a disabled Hun, and that he knew of no friend that had ever tarnished the principle of fair play.

love of aviation, and under different circumstances may have even befriended one another, in the air these attachments rarely derailed their pursuit of victory.[60]

And what of the "fighter pilots diving, climbing, turning" that so enchanted the dreams of later youths like Blesse?[61] They may have been there early in the war, but as more and more aviators were thrust into battle, and as tactics premised on surprise proved successful, the importance of aerobatics for anything other than simply gaining familiarity and confidence in a new aircraft quickly waned.[62] Richthofen professed only disdain for those that chose to engage in a swirling dogfight, writing "We need no aerial acrobats; rather, daredevils."[63] Although large swirling maelstroms of fighters might still occur, they, like Udet's observed acts of charity, were becoming a rarity. Another British pilot reported a few months later, "The days of dogfights where machines rush at one another and circle around each other, firing all the while, seem to be gone."[64]

Thus, despite the popular portrayals, the majority of air combat over the Front was not a aerobatic sport arranged between friendly competitors. It was rather "the exact antithesis of the 'sporting attitude,'" in the words of one American pilot; "an attempt to figure out a system whereby the enemy has no chance."[65] And that *system* needed more than just a courageous and gifted pilot; it relied on his marriage to a set of tactics and a powerful machine adequately armed. One image in particular captured this reality, a wartime advertisement for Fokker aircraft in which the man and the machine merge at the gunsight, becoming almost indistinguishable, while a Blue Max medal, symbolizing glory and fame, beckons from above (figure 2.1).[66]

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[60] Once the enemy aviators were disarmed of their machine, they could be afforded the customary courtesies granted military officers. For example, Boelcke during an engagement on January 7, 1916, successfully downed a British two-seater. The German pilot landed nearby and ran to the "enemy machine…. I went straight up to the Englishmen, shook hands with them and told them I was delighted to have brought them down alive. I had a long talk with the pilot, who spoke German well. When he heard my name, he said with a grin: 'We know all about you!'" Quoted in Werner, *Knight of Germany*, 161–62.

[61] Blesse, *Check Six*, 56.

[62] Deullin, "Pursuit Work in a Single Seater," 1. Deullin for one declared that a single-seater pilot "should be before everything else skillful in maneuvering. He can never practice too much aerial acrobatics."

[63] Quoted in Kilduff, *Richthofen*, 236–39. A few paragraphs later in a section on "Individual Combat," Richthofen makes the statement, "One does not need to be an aerobatic artist or a trick shooter; rather, to have the courage to fly right up to the opponent."

[64] Hart, *Aces Falling*, 53, 91. One large engagement on March 18, 1918, left a British pilot "quite unnerved," echoing to himself, "Frightful affair, frightful affair."

[65] Wentworth, "Lectures by Pursuit Pilots," 2.

[66] Fritzsche, *Nation of Fliers*, 68.

Man and Machine (and Tactics)

No doubt individual skills like superior airmanship could prove valuable in combat. Powerful eyesight and the ability to detect "just a twinkle of the sun on a bit of metal" were likewise cited as skills "of paramount importance" that would extend a pilot's longevity and help him bolster his tally of kills.[67] Nevertheless, while a pilot possessing the aerial sense of Richthofen or McCudden or the visual acuity of Mannock might do well patrolling alone, his chances of survival and success were much higher if he instead elected to roam with others.[68]

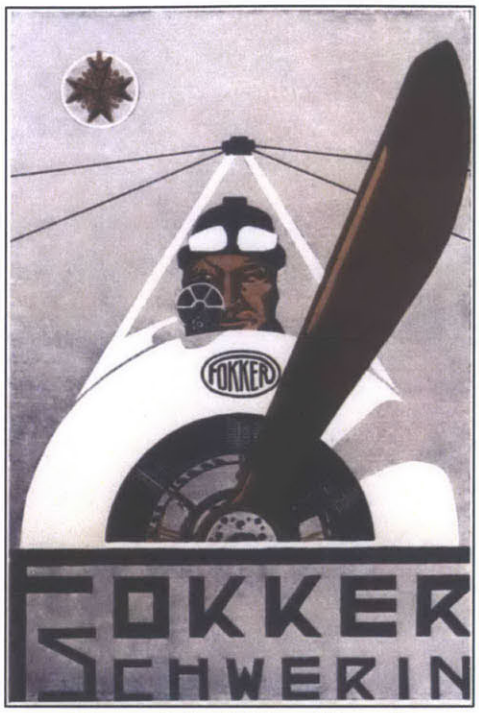

Figure 2.1. Fokker Aircraft Advertisement, World War I.
(Source: Wohl, *Passion for Wings*, 202).

Early experiments at coordinated action among fighter aircraft focused simply on setting traps: an inexperienced pilot was told to fly slightly below and in front of his leader, who promised to dive down and "make short work" of any "unsuspecting enemy" that took the "bait."[69] However, with the emergence of the Germans' offensively oriented *Jagdstaffeln* under the leadership of Boelcke, more advanced fighter tactics quickly emerged. By the time of Richthofen, McCudden, and Mannock, the lone patrolling fighter on both sides of the lines had become extinct. All, including the legendary aces, now prowled in "triangular" formations of varying size.[70] Upon finding an enemy aircraft, the group of planes would descend on the unlucky foe "like a pack of bloodthirsty

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[67] Wentworth, "Lectures by Pursuit Pilots," 4.

[68] Hart, *Aces Falling*, 42, 51, 54–55, 59. Of course, roaming with others could also lead to a mid-air collisions, as Boelcke and Böhme learned.

[69] *Pursuit Text*, 27 1/2.

[70] Werner, *Knight of Germany*, 198–99. Prior to Boelcke's *Jagdstaffeln*, pilots either flew as isolated combatants or they were told to accompany and protect non-fighter aircraft such as reconnaissance or bomber aircraft. On the significance of the *Jagdstaffeln*, see Fritzsche, *Nation of Fliers*, 70–71; Franks, "Introduction," 3–4. On the "triangular" formations, see Deullin, "Pursuit Work in a Single Seater," 7; Deullin, "Chasseur Patrols," 1; *Pursuit Text*, 41–43. Deullin alluded to the initial transition: "After some fruitless and even painful attempts, our hunters were forced to admit that the time of the solitary single seater has passed and the we had to look for something else." Within the formation, pilots followed their leader about "500 yards behind and 100 yards above."

foxhounds who had caught up with their prey."[71] The American pilots likened the experience not to a duel but to "gang fighting."[72]

It wasn't pure bedlam, though. Rules and roles were quickly established to maximize the formation's efficacy and efficiency. New pilots were paired with those more experienced, providing the new recruits with an opportunity to learn first-hand "certain essentials" of air combat.[73] The arrangement, however, was predicated on strict discipline within the formation, a quality antithesis to the classic portrayal of the daring flyer. Boelcke addressed the paradox explicitly in his *Dicta*, declaring: "Foolish acts of bravery only bring death. The *Jasta* must fight as a unit with close teamwork between all pilots."[74] A standing order within British Major Sholto Douglas's unit declared, "No pilot was on any account to leave the formation, even to take on what looked like an easy opportunity to shoot down an enemy aircraft."[75] The Americans adopted a similarly stern approach, explaining, "It is the patrol leader only who should have the thinking part until contact with the enemy is gained. Before this time the pilot's place is to follow."[76]

The initial attack was highly scripted. The leader signaled his decision to pounce by wiggling his wings. Then, adopting language usually reserved for descriptions of warfare in the trenches below, each accompanying pilot immediately assumed "his part as cog in the prearranged scheme."[77] As the leader dove to attack, the accompanying pilots all followed him, protecting his rear.[78] Douglas later described the rationale, "Being the most experienced of all the pilots, the leader was the most capable of shooting down the enemy quickly and effectively; and with the squadron behind him and acting as a buffer against any attack from the rear he could afford to concentrate all his powers on the destruction of the enemy

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[71] The description by Captain Leonard Rochford, RNAS, is cited by Hart, *Aces Falling*, 103.

[72] Wentworth, "Lectures by Pursuit Pilots," 2.

[73] Ibid., 1. This "minimize[d] in so far as possible the undesirable necessity of [the new pilot's] solving situations as seem best to him at the moment. They are based on the fact that similar situations have been encountered before, the possibilities analyzed and the method of dealing with them incorporated in the essentials."

[74] Boelcke's *Dicta* is included in Franks, "Introduction," 5.

[75] Quoted in Hart, *Aces Falling*, 53.

[76] Wentworth, "Lectures by Pursuit Pilots," 1, 4. Wentworth warned the Americans, "a pilot breaking from his formation to give combat … jeopardizes the safety and efficiency of all."

[77] Ibid.

[78] Deullin, "Pursuit Work in a Single Seater," 7; Wentworth, "Lectures by Pursuit Pilots," 3; Hart, *Aces Falling*, 53–54.

without having to peer all the time over his shoulder."[79] Thus, for Douglas, the leader provided the offensive capability; the accompanying pilots were there for defensive purposes. This particular model of formation air attack would survive for decades.

Although all adhered to the principle, not all enforced Douglas's division of labor as strictly. The Frenchman Deullin offered his pilots slightly more leeway, alerting them to "some splendid opportunities" that may arise for the "protector" who doesn't follow his leader "too blindly or too closely."[80] The Americans also offered more autonomy to their younger pilots: "The leader opened the attack," one pilot recalled, "but from there on, the individual acted as he thought best." Still, the message was clear: "A pilot is an asset just so long as he remains part of [the formation] unit."[81]

These well-crafted tactics that linked otherwise isolated pilots to one another facilitated greater overall effectiveness during both attack and defense. But the tactics, as well as any individual's unique flying skill, were of little use if the pilots were not flying capable aircraft. As one American report noted after the war: "No matter how stout of heart a pilot may be, he is at the mercy of the plane he flies; all his skill and courage avails nothing should his motor stop."[82] At the outset of war, the best fighters (produced by the French) reached speeds of seventy mph, powered by a 70- to 85-hp engine, and they possessed only the armament that an observer could carry aboard: carbines, revolvers, grenades, and occasionally bricks (figure 2.2). By early 1918, a 185-hp BMW 3a engine enabled the German Fokker D.VII to reach speeds in excess of 120 mph, and the pilot had two fast-firing

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[79] Quoted in Hart, *Aces Falling*, 53–54. Douglas's description of battle was not published until 1963, but Deullin's 1917 report provides historical support for Douglas's stated rationale: "The guid [*sic*] gives the signal for the attack and his comrade follows him, keeping his distance and protects his rear." Deullin, "Pursuit Work in a Single Seater," 7.

[80] Deullin, "Pursuit Work in a Single Seater," 7.

[81] Wentworth, "Lectures by Pursuit Pilots," 1–2. Richthofen also granted significant freedom to his accompanying pilots once the battle had begun, telling them, "From the moment the commander dives on an enemy squadron, each pilot should be intent on being the first to engage the enemy." Quoted in Hart, *Aces Falling*, 46. In the event the formation came under sudden, surprise attack, the initial defensive maneuvers were, like those for the attack, also largely predetermined; see: Wentworth, "Lectures by Pursuit Pilots," 2; *Air Service Pursuit and Combat Manual*, 6.

[82] Milling, *Air Tactics*, sec. 6, p2. See also *Pursuit Text*, 87.

machine guns mounted directly in front of him (figure 2.3). In a span of just over three years, aircraft performance had nearly doubled.[83]

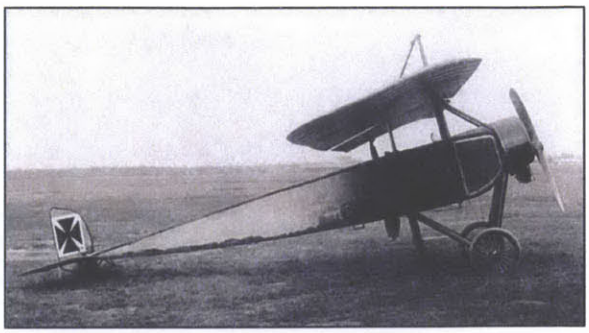

Figure 2.2. French Morane-Saulnier Type L, 1915.
Garros modified this type aircraft for single-seat aerial combat. This particular aircraft was captured by the Germans; hence the insignia on its tail. (Source: www.century-of-flight.net)

For the individual pilot, the quickening pace of aviation development translated into a wartime experience spent trying to master several distinct aircraft, all possessing different flight characteristics and strange quirks. For example, those who took to the skies in the famed British Sopwith Camel learned quickly that it "was a very tricky aeroplane to fly."[84] Still, given the choice between continuing to fly a plane a pilot was already comfortable with and wringing out a new, unproven, and potentially dangerous aircraft, the majority of pilots opted for the uncertain promise of the latter.[85]

Figure 2.3. German Fokker D.VII, 1918.
(Source: US National Air and Space Museum)

But, improvements in engine horsepower and aircraft performance that made it easier for a pilot to position himself behind his foe were for naught unless that pilot could then bring down his prey with a stream of well-placed bullets. After all, "the pursuit

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[83] Morrow, *Great War in the Air*, xv, 60, 300–302, 315–16. On the superiority of the Fokker D.VII, Morrow noted that it possessed "an apparent ability to make a good pilot out of mediocre material." See also Crouch, *Wings*, 168.

[84] Quoted in Hart, *Aces Falling*, 38–39. Hart teased that the Camel's unpredictability could be of benefit in combat: "If the pilot barely knew what was happening how could his opponent?"

[85] Morrow, *Great War in the Air*, 217–18; Wohl, *Passion for Wings*, 228; Holley, *Ideas and Weapons*, chap. 7; "Report of the Chief of Staff," 137. In a letter penned to a friend in mid-1917, Richthofen bemoaned of his old Fokker D.V: "I can assure you that it is no longer any fun being leader of a fighter unit.... Our airplanes are inferior to the English in a downright ridiculous manner.... Our fighter pilots, though quite good, are consequently lost! The D5 is so antiquated and laughably inferior that we can do nothing with it.... You would not believe how low morale is.... No one wants to be a fighter pilot any more." Senior leaders recognized the importance of technological superiority (or at least equivalency) in the air. The American Army Chief of Staff in his 1917 report to Congress complained of the difficulties his service experienced getting suitably modern aircraft into the war, lamenting "a machine to-day is obsolete to-morrow."

airplane," one American post-war report noted poignantly, "is a flying machine gun" with one mission—"to destroy any type of hostile aircraft encountered."[86] For Richthofen, a "well-firing machine gun" was "better than a smooth-running engine," and becoming a "master" of the gun was the quintessential fighter pilot responsibility.[87] Subjected to jarring flight conditions and short, frequent firing bursts, misfires and gun jams were a frequent occurrence, and pilots were encouraged to learn how to repair their jams "quickly in the air." Those that "neglected this essential principle," Deullin explained, "always regretted it."[88]

For the majority of the war, it was a pair of .30-caliber machine guns with a high rate of fire that remained the pilots' preferred armament. There was some variation, though. For example, on the SE5, the British elected to mount a lighter-weight Lewis machine gun on the upper wing and retain a single Vickers machine gun on the top of the fuselage. A trigger on the control stick allowed the pilot to fire both guns.[89] Other aircraft designs experimented with incorporating more machine guns or larger-caliber weapons, but the added weight of the extra guns severely degraded the aircraft's performance with no noticeable benefit in firepower effect. The Americans eventually concluded that it wasn't the size of the bullet, but the "maximum number of effective rounds per second" that proved of "ultimate" significance.[90]

As the designers toyed with varying gun arrangements, they also searched for new tools to improve the pilots' "appalling" aim.[91] One was a telescopic glass sight, referred to as a "Chretien collinateur" by Deullin. Approximately twenty-eight-inches long and one-and-a-half inches in diameter, stuffed with "a series of lenses and prisms," the sight promised to help pilots estimate the amount of lead fire required to score a hit against a target moving at various angles and airspeeds. However, based on Deullin's nearly page-long, tortured attempt at describing the sight's operation, it is doubtful that it was ever used to its full potential. Deullin's assessment of the sight, buried within his description, was telling: "He who spends too much time trying to work out the proper correction will find the chance

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[86] *Pursuit Text*, 107.

[87] Quoted in Kilduff, *Richthofen*, 237; Hart, *Aces Falling*, 47.

[88] Deullin, "Pursuit Work in a Single Seater," 8.

[89] Hart, *Aces Falling*, 38–39.

[90] *Pursuit Text*, 152–58.

[91] Hart, *Aces Falling*, 61–62.

gone.... Most pilots rely on their tracer bullets."[92] An American report likewise dismissed the utility of the telescopic sight, noting that it frequently fogged over due to accumulated moisture within the tube, and that its use demanded "too much attention" and "encouraged many pilots to open fire at too great a range."[93]

Far easier to understand and use in the heat of battle was the classic open ring-and-bead (or ring-and-post) sight, seen in the popular Fokker advertisement (figure 2.1). Akin to aiming a rifle, the pilot steered his plane to first align the target under the far bead and then to center both target and far aiming reference in the nearer ring. There were challenges associated with using the simple sights: any head movement by the pilot would yield different aim points, and the pilot also had to constantly shift his eye focus from the distant target to the near sight and back again.[94] But, despite its inaccuracies, the sight had the indisputable advantages of being "simple to construct, install and adjust, [and] fairly sturdy and reliable." Moreover, with the majority of battles taking place inside of 100 yards, and with pilots instructed to move closer if possible, the sight didn't need to be that precise.[95] To help them judge the distance to the target so they knew when to open fire, many pilots carved "a series of notches across the top of the fuselage at right angles to the direction of flight" to serve as a "crude but effective range finder"; the spacing between the notches corresponded to "the wing spread of the type of hostile airplane most frequently encountered ... at varying distances."[96]

Once in range and the pilot commenced firing, he adjusted his aim by steering his aircraft to achieve "a good sprinkling" of bullets over the target, hoping that one might prove lethal.[97] Some aviators were obviously better than others. One pilot commented, "I have seen pilots 'sitting on the tail' of enemy machines, and only a few feet off, fire away all

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[92] Deullin, "Pursuit Work in a Single Seater," 7–8. Furthermore, Deullin acknowledged that "it is utterly impossible in practice to do more than approximately estimate speeds and distances." On the advantages and disadvantages of using tracer ammunition, see *Pursuit Text*, 179–180.

[93] *Pursuit Text*, 164–65.

[94] *New Developments*, 30.

[95] *Pursuit Text*, 163–65. The text noted, "At such [close] ranges elaborate sighting devices are unnecessary since the direction of flight and the trajectory of the bullets are almost coincident."

[96] Ibid., 164.

[97] Deullin, "Pursuit Work in a Single Seater," 7. Deullin however noted that one could "do too much sprinkling, and in one's anxiety and haste, to use the machine gun as a sort of hose with which to spray the sky."

their ammunition, and still the Hun tootles along unhurt. Then again, I have seen a careful pilot fire only about 10 shots—and down goes his opponent."[98]

Questionable Glory

The combination of "gang fighting" tactics and the preferred method of spraying bullets at a target hoping for a lucky shot produced a situation ripe for confusion when it came to awarding credit for a victory. As a consequence, the simplicity and objectivity of the aerial victory, a key component of the fighter pilot myth that so entranced the populace, was illusory. While each nation attempted to guard against inflated victory claims by requiring confirmation by other-than-the claiming pilot, as Hart noted, the chaotic nature of mass air combat meant that all pilots, "one way or another, over-claimed."[99] There was also little incentive to guard against inflated totals. In an environment where numbers of confirmed kills became the measure of the fighter pilot, and the fighter pilot was in-turn seen as a measure of the nation, the immense pressure to post superior numbers wasn't limited to just the individual aviator. For example, when Mannock was killed in July 1918, he had only amassed sixty-one victories before Royal Air Force leaders elected to posthumously award him credit for an additional twelve kills. The tweaking "coincidentally" pushed Mannock's total to one more than the Canadian Major "Billy" Bishop, thereby ensuring that an Englishman went down in history as Great Britain's Ace of Aces.[100]

The attention devoted to recording victories and achieving ace-hood significantly distorted the other important contributions of fighter pilots, as well as those of their brethren who were flying reconnaissance and bomber aircraft.[101] For example, in April 1918 as the Germans were launching their latest spring offensive, Allied fighter pilots were told by their Supreme Commander Foch that their "first duty is to assist the troops on the ground,

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[98] Quoted in Hart, *Aces Falling*, 61–63, 196, 335–336. Of course, the pilot could also always resort to ramming the enemy plane, as American Wilbur White elected to do on October 10, 1918. Rickenbacker recalled: "White rammed the Fokker head on while the two machines were approaching each other at the rate of 250 miles per hour! It was a horrible yet thrilling sight. The two machines actually telescoped each other, so violent was the impact. Wings went through wings and a first glance both the Fokker and Spad seemed to disintegrate."

[99] Ibid., 59–60. Contributing to the problem, Hart noted that "quarrels over claims were avoided and many squadrons had a cheerful 'You scratch my back, I'll scratch yours' attitude to the formal confirmation of kills." See also Hart's description of a hypothetical mission and the confusion over aerial victories that logically resulted when pilots followed their leader during an attack.

[100] Ibid., 204. Mannock received his Victoria Cross posthumously in 1919.

[101] On the larger contributions of aviation within the Great War, see Morrow, *Great War in the Air*.

by incessant attacks, with bombs and machine guns.... Air fighting is not to be sought so far is necessary for the fulfillment of this duty."[102] By the time of Foch's message, though, fighter pilots had already begun flying low over the trenches dropping small bombs and strafing enemy troops and supplies.

They did it, but they did not like it. It was considered a more dangerous mission, partly because the pilots had less control over their own survival. During "these low-level missions," one pilot revealed, "one became a mere target to be shot at all the time and it was a matter of sheer luck whether one got hit or not." Consequently, many pilots simply tried to empty their ammunition belts "as quickly as possible," preferably on a single diving pass, so they could then return home.[103] There was also another reason why the pilots despised the mission. One confided: "If a pilot can shoot down several enemy aircraft observed to crash, he gets personal credit and possibly a decoration. If he does equally or more valuable work for a month by shooting up transport vehicles, troops or aeroplane sheds, his feats tend to be included in the general results of the flight or squadron.... The individual has no confirmed and positive result to show. This 'individualism' is not talked about; it may be petty, unmilitary and regrettable, but it exists."[104] For the fighter pilots, to fly and fight in the air brought fame, but to gun down an enemy soldier in a trench brought only increased risk. Thus, although the aerial victory credit may have been ambiguous in practice, the reward system that accentuated it was not, and the effects therein could be pernicious.

In the end, the aces did account for more than their fair share of aerial victories, but they never matched the uplifting rhetoric that was purportedly based on their exploits.[105] Their victories, while quantifiable, were neither objective nor necessarily accurate.[106] The pilot's flying skills, their vision, and their marksmanship mattered, but only when paired with a capable aircraft. They may have flown alone in their aircraft, but they roamed the skies in

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[102] Hart, *Aces Falling*, 138.

[103] Quoted in Ibid., 119. Flying over the maze of trenches, pilots also had a difficult time distinguishing enemy from friendly troops; flying low enough to do so rendered the pilot "more vulnerable."

[104] Quoted in Ibid., 121–22.

[105] *Pursuit Text*, 25; Crouch, *Wings*, 164–65. One post-war American report figured that the sixty-five leading aces from the various belligerent nations accounted for 2,069 destroyed aircraft, while the remaining 609 aces of the war downed an additional 7,279 aircraft.

[106] Hart, *Aces Falling*, 204. Hart noted that with each nation possessing its own constellation of star-aces, and with their individual capabilities often mitigated by periods of waxing and waning technological superiority, the aces' collective effect over the battlefield was usually "redundant" and offsetting.

gangs. And although they may have lived a life of privilege at 10,000 feet, they were still within easy reach of death's grasp, which often arrived via a bullet in the back.[107] Moreover, the myth ignored the symbiotic relationship that was being forged between the fighter pilot and his machine. In combat the pilots rarely recognized the man; they saw only the machine. The popular narrative, in contrast, acknowledged only the man; the machine resided in the hazy background. Yet it was only in combination that either could function. Without his aircraft, the pilot was doomed to an ignominious life as a youth too feeble for the army (Guynemer) or transporting generals between command stations (Rickenbacker). And without the pilot, the new, more powerful airplanes simply sat on the grass.

Yet the myth of the self-reliant fighter pilot who could capture glory in an aerial duel against an even-matched foe proved powerful. German General Erich Ludendorff is said to have remarked that the Red Baron "was worth as much as two divisions of German Infantry."[108] It was not Richthofen the pilot per se, but Richthofen the carefully crafted symbol Ludendorff was referencing. The myth, not the pilot, inspired pride in his fellow troops and countrymen. In the ensuing decades, the symbolism of the great fighter pilot aces like the Red Baron would continue to exert a powerful influence over future flyers, especially within the United States.

Ritualizing the Myth

Following the First World War, the United States experienced an explosion in popular enthusiasm for all things aviation. Hollywood epics recreated on the silver screen the fabled aerial engagements of the war's ace-flyers.[109] Newspapers trumpeted pilots' record-setting jaunts to higher altitudes and faster speeds and traversing longer distances,

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[107] Fritzsche, *Nation of Fliers*, 85. Fritzsche cited a German cartoon that "aptly represented fliers as 'the upper ten thousand,' a class as remote and exempt in war as the *haute bourgeoisie* had been in peace."

[108] *Pursuit Text*, 25; Burrows, *Richthofen*, 141.

[109] Notable films included Howard Hughes' "multi-million dollar air spectacle" *Hell's Angels*, which premiered on May 27, 1930. *Dawn Patrol*, released a few months later, likewise incorporated spectacular aerial footage. Neither, though, matched the excitement and spectacle that was *Wings*, released three-years earlier in August 1927. One critic noted of the earlier film: "This feature gives one an unforgettable idea of the existence of these daring fighters—how they were called upon at all hours of the day and night to soar into the skies and give battle to enemy planes; their light-hearted eagerness to enter the fray and also their reckless conduct once they set foot on earth for a time." *Wings* went on to win the first-ever Academy Award for Outstanding Picture. "Hell's Angels"; "Dawn Patrol"; "Wings"; Hall, "Screen: Sky Battles"; Hall, "Screen: The Flying Fighters"; Wohl, *Spectacle of Flight*, 114–32, 139.

especially Charles Lindbergh's trans-Atlantic crossing of May 20-21, 1927.[110] Freshly published memoirs and pulp fiction stories, including Blesse's and Olds' favorite series *G8 and his Battle Aces*, likewise fueled the nation's appetite for exciting aerial adventure.[111] Meanwhile, flyers fresh from France barnstormed out across the nation in army-surplus JN-4 Jenny's evangelizing what Joseph Corn later termed the "winged gospel."[112] During this period, a remarkable shift in the persona of the civilian pilot occurred, as the image of the pilot as daredevil, "intrepid birdman," or "modern superman" was consciously recrafted to bolster aviation's mass appeal for other than spectator purposes. This concerted push to democratize aviation was reflected in one encouragement from the time, "You and I and cousin Libby can all be Lindberghs."[113]

There was, however, no corresponding transformation in the military realm. If anything, the image of the "birdman" pilot became more institutionalized and ritualized within the military during the interwar years, reinforcing the image of the fighter pilot ace as a daring and uniquely skilled aviator. For example, a 1929 Air Service text commented on the war's important lesson of assigning "only the best" and "most skillful pilots" to the "faster, lighter and more maneuverable" fighter aircraft. "The successful pursuit pilot," the text noted, "must be an individual whose qualifications peculiarly fit him for the type of work to be performed." The text also reasserted the "knight of old" analogy, referring to the aerial war as being "more … a sporting proposition" where "wholesome respect was felt for worthy opponents" and a "spirit of chivalry prevailed."[114] Although the aviators likely knew better, there was little incentive in rewriting the popular narrative so carefully crafted years earlier; they were enjoying the esteem of the nation and their fledgling institution was locked in a struggle for scarce dollars within a torpid Army bureaucracy.[115]

Military aviation was different than civilian flying, military flyers contended, and consequently they rebuffed the prospect of mollifying the military aviation experience to

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[110] Corn, *Winged Gospel*, 20–25; Wohl, *Spectacle of Flight*, 29–37.

[111] The works of *Aéropostale* pilot and budding French literary genius Antoine de Saint-Exupéry also appeared during this period. Wohl, *Spectacle of Flight*, chap. 4.

[112] Corn, *Winged Gospel*, x, 12–13, 16–17, 30, 136–38.

[113] Ibid., 74–88. Corn concluded that it was "the female pilot [that] became the antidote for the intrepid birdman stereotype."

[114] *Pursuit Text*, 23–24, 27, 46.

[115] On the post-war issues of the American military aviation establishment, especially during the air mail crisis in early 1934, see Nalty, *Winged Shield, Winged Sword*, 122–27. See also Johnson, *Fast Tanks and Heavy Bombers*.

match that of the democratizing civilian sector. "You can teach anybody to fly but you can't make pilots out of them," became a common rejoinder of military flight instructors.[116] As one aviator realized midway during his training, to be a military pilot demanded something that couldn't be taught: "You weren't even being tested on something you studied, really, but on what you were. If you were a flier, you passed; if you weren't you washed out—fell out of the air, and became a lower order of being.... Some people were natural fliers, and some weren't."[117]

Determining the physical, emotional, and intellectual attributes that predestined an individual for greatness as a "flier" in fighter aircraft became a major topic of study for the military. Late in the Great War, the prestigious British medical journal *The Lancet* published a profile of the successful fighter pilot: "usually the enthusiastic youngster, keen on flying, full of what one might call the 'joy of life,' possessing an average intelligence, but knowing little or nothing of the details of his machine or engine." Foremost, the fighter pilot needed to be "endowed to a high degree with the afore-mentioned quality, 'hands'"—which the authors described as a "congenital" trait, similar to that of a "horse-rider," that permitted the pilot to sense "unconsciously the various movements of the aeroplane" and correct "any unusual or abnormal evolutions almost before they occur."[118] Almost a quarter-century later, the military's assessment of fighter pilots had changed little. A 1942 article published by the Army Air Force's Air Surgeon's office noted that: "The *pilot* must have the ability to learn complex motor skills involving gross muscular coordination. In addition to this, it is desired that the pilot exhibit superior speed of reaction and the ability to make quick and accurate observations and judgments. While he should be confident and aggressive to be a fighter

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[116] Jeon, "Technologies of the Operator," 148. Jeon cites a meeting on the "Selection and Training of Aircraft Pilots," 25-26 May 1941: "The military did not look 'merely for the men to fly but for men who know how to take it after they know how to fly.' ... A pilot was someone 'who can stand the gaff'" (emphasis in original).

[117] Cameron, *Training To Fly*, 395. Although citing a Navy pilot, Cameron notes that the Army and Navy flight training regimens were comparable in this respect.

[118] Rippon and Manuel, "Report on the Essential Characteristics," 411–12. The authors explained their rationale for the pilot "knowing little or nothing" of his aircraft: "The less the fighting scout pilot knows about his machine from a mechanical point of view the better. From the very nature of his work he must be prepared to throw the machine about and at times subject it to such strains that did he realise how near he was to the breaking-point, his nerve could go very quickly." The pilot profile also noted that "he has little or no imagination, no sense of responsibility, keen sense of humour, able to think and act quickly." See also Cameron, *Training To Fly*, 131; Mitchell, *Winged Defense*, 164.

pilot, he should also be mature and have the ability to command."[119] In short, regardless of what may have transpired in the civilian sphere, fighter pilots, according to the military, still needed to be uniquely endowed male specimens.

Selecting individuals for military flight training based on their aggressiveness and self-confidence proved problematic. Already inculcated into the myth of the fighter pilot as celebrated in the popular movies, books, and comics of the day, many of the young and pugnacious aviation cadets experienced a rude awakening when they were inserted into a flight training regimen predicated on strict discipline. "Training had to rein in the young hotspurs," but it also had to do so without squelching the cadets' aggressive spirit prized by the service.[120] Those that struck the proper balance and continued to demonstrate supreme self-confidence were rewarded with the service's most cherished aircraft—single-seat fighters.

But, the process wasn't always the most objective. One instructor recalled of the assignment process: "We'd say, 'Well this fellow is aggressive and he ought to go to fighters.'"[121] Robin Olds experienced the subjectivity firsthand. His "hopes for a fighter pilot career dashed" by an impulsive senior officer who declared him unfit for fighters, Olds later earned the respect of his flight instructor and was rewarded with a fighter assignment after he flew "under every bridge on the Hudson from Albany to New York City," a bold but fortunately successful gamble.[122] Many other budding fighter pilots, not as skilled as Olds or perhaps not as lucky, paid the ultimate price when they tried to prove their fighter worthiness. Going through training in the 1930s, one flyer remembered that of the ninety-six other graduates of his flight training course, "within a year, fifteen were dead. Crashes—mostly pilot error, and most of it was from high-spirited behavior.... Doing stunts, flying under things, flying low, especially, and pulling up."[123]

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[119] Flanagan, "Selection and Classification Program for Aviation Cadets," 231; Jeon, "Technologies of the Operator," 104, 110.

[120] Cameron, *Training To Fly*, 2, 539. Cameron noted the paradox: "The air arm ... glorified the individual, specifically the warrior-pilot who flew against extremely dangerous odds, in training as well as in combat. The flight training program formulated rules and regulations in part to defy air force culture, in that training procedures attempted to curb the eccentric, the dangerously individualistic, the tendency for airmen to rely only on themselves and each other."

[121] Ibid., 403–4.

[122] Olds, *Fighter Pilot*, 15–16.

[123] Cameron, *Training To Fly*, 272. Yeager rationalized the "gruesome weeding-out process.... Those who were killed in Nevada [during training] were likely to have been the first killed in combat." Quite simply, some

By the late 1930s, the ascendency of the strategic bomber in airpower doctrine began to threaten the princely status of the fighter pilot. Offensive action, the airpower advocates at the Air Corps Tactical School at Maxwell AFB in Alabama determined, was now to be the purview of the team of men crowded into the fuselage of heavy bombers. Rather than attack plane-for-plane with fighters, it was far more efficient, the doctrinaires preached, to knock enemy fighters out of commission while they were on the ground at their airfields; even better still would be to attack the aircraft when they were still parts or raw materials waiting to be assembled or manufactured. In this model of future air combat, small single-seat fighters would play at most a defensive role.[124]

Nevertheless, the fighter pilot myth persisted and the majority of pilots continued to long for fighters. Describing the popular sentiment, one pilot commented, "to choose any course except single-engine planes … would have seemed cautious, unromantic, almost middle-aged, like wearing your rubbers or voting Republican."[125] The allure of self-reliance symbolized by the single-seat cockpit was a significant motivator, as it had been decades earlier for Boelcke. So too was the nagging worry of being trapped in a lumbering bomber, unable to maneuver, about to be gunned down by an enemy fighter.

War's Next Test

Walker "Bud" Mahurin was, like Olds, originally slated for bombers when he completed initial flight training in early 1942. Horrific losses in the first daylight bombing raids over Europe had resulted in a sudden and severe shortage of bomber pilots. For trainees like Mahurin, that meant "it didn't make much difference to the authorities what the individual wanted, he was needed in bombers and to bombers he would go." The young twenty-three-year-old from Fort Wayne, Indiana, was not thrilled about the assignment. "Nothing could make up for my disappointment.... I simply didn't like being a bomber pilot. It seemed that all we did was fly around the sky in a big gaggle of aircraft." Then, fate intervened. The day of graduation, Mahurin's class was told that anyone shorter than five-

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people were made to be fighter pilots, and the others who weren't who killed themselves trying to be rightfully earned disrepute "for destroying expensive government property as stupidly as if they had driven a Cadillac off a bridge." Yeager, *Yeager*, 15.

[124] O'Mara, "Socio-Technical Construction of Precision Bombing," 52–54.

[125] Cameron, *Training To Fly*, 400.

feet, ten-inches was being reassigned. Granted, it wasn't the typical method for assigning aircraft, but Mahurin was ecstatic: "I was 5'9½". Fighters after all!"[126]

After some additional training, Mahurin found himself a member of the 56th Fighter Group, the first P-47 Thunderbolt unit sent to the European theater. Arriving in England in early 1943 and piloting the "nation's newest and most powerful single-engine flying machine," Mahurin quickly distinguished himself as the first American pilot to down ten enemy aircraft in the skies over Germany and France.[127] But once in Europe, Mahurin soon realized that the reality of air combat didn't quite match the popular rhetoric and imagery he had grown up with. As one of the leading aces at the end of 1943, Mahurin was asked to contribute some words of wisdom for a new manual on air combat. He chose to address the discrepancy explicitly:

> In my opinion aerial combat isn't half of what is shown to be in the movies.... We like to think that the battle will assume proportions equal to those of the movies. You know how it is—one pilot sees the other, they both grit their teeth to beat hell, and finally the deadly combat begins with violent maneuvering by both parties. This field of thought is entirely erroneous. The combat usually takes place at a hell of a speed; the enemy plane is only seen for a few seconds. In nine cases out of ten the victor never sees his victim crash. As a result of the wrong idea, the new pilot who first sees a Jerry [German] ship, goes in to attack hell bent for election, and winds up feeling futile as the dickens because he didn't even succeed in frightening the Hun. I know, because I've done it myself many times.[128]

In fact, many of Mahurin's experiences of air combat over Europe mimicked those of the ace-flyers from the First World War. For one, although now flying in an aircraft that

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[126] Mahurin, *Honest John*, 109, 115–16, 118–19.

[127] Ibid., 118, 123–24, 132. Before achieving ace-hood, Mahurin distinguished himself in a more infamous manner. Still new to the theater and looking for a thrill, Mahurin closed to within a few feet of a lone B-24 bomber and exchanged waves with the crew. Planning to descend below the large bomber and then accelerate away from it, Mahurin's tail was instead clipped by the bomber's propellers. Mahurin's plane was destroyed (he jumped out of it using his parachute). He was ordered to pay a $100 fine for "use of governmental equipment prejudicial to the best interest of the United States."

[128] Mahurin, "Major Walker M. Mahurin," 23–25. Reprinted in Mahurin, *Honest John*, 130–32. Mahurin's advice, along with that of the other leading aces, would not be distributed until May 1944. It was accompanied by a note from the Eighth commander that the accompanying "outline of the technical phases of long range fighter escort" did not diminish the pilots' "determined, courageous, and skillful battle." Kepner, "Major General W.E. Kepner," 3. Olds likewise recalled the influence of the media on his image of a fighter pilot. After downing a FW-190, Olds "buzzed" and then did "two victory rolls" over the German pilot; "then I felt like an ass doing such a silly, damned-fool, kid thing like that. Obviously I'd read too much of Hogan's *G-8 and His Battle Aces* and watched too much of *Wings* and *The Dawn Patrol*." Olds, *Fighter Pilot*, 83.

routinely reached speeds six times that of Garros's Morane monoplane, and which now packed the striking power of eight .50-caliber machine guns, Mahurin along with most of his squadron-mates still needed to get excruciatingly close to their target to ensure a kill. On a few occasions, he was able to score hits from 500 yards, but more frequently, he teased, "I have to get close enough to the Hun to reach out and club him before I can hit him. Usually, even that won't work."[129] When it did, it was close enough to see the after-effects of the engagement, revealing that he was shooting down people, not "objects." On one occasion, he saw a German pilot try to jump from his flaming plane, only to have his foot get pinned in the cockpit: "the rest of his body [was] sprawled back along the top of the fuselage. His arms were flapping wildly in the airstream." Mahurin admitted, "It shook me badly."[130]

Moreover, although eventually equipped with better gunsights (which will be covered in the next chapter), the practical instruction on fighter gunnery during the Second World War remained remarkably similar to that from 1916. Major "Tommy" McGuire, who would become for a period the second top-scoring American ace in the Second World War before being killed over the Philippines in January 1945, advised his pilots, "Go in close, and then when you think you are too close, go on in closer."[131] Echoing Deullin's decades-earlier advice to deliver "a good sprinkling" of machine gun fire over the enemy, Captain Reade Tilley in 1943 recommended that pilots "close in to very short range, center the aircraft's wing span in your windshield, then commence firing and pump the stick gently back and forth."[132] And, as before, pilots were instructed that it was best to achieve a close-range position through surprise attack. Missing that one critical element of a successful "bounce," Mahurin said, and "Jerry is about ten times as difficult to bring down."[133]

Surrendering a measure of individual autonomy to fly in formation was another similarity, as were the formations themselves. The pilots, like their predecessors, were

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[129] Mahurin, *Honest John*, 118, 124–25, 131; Mahurin, "Major Walker M. Mahurin," 25.

[130] Mahurin, *Honest John*, 125–27. Olds similarly remembered of his combat experience, "The airplane was a target, not a man. It was a surprise when a body would suddenly come flying out of the stricken bird." Olds, *Fighter Pilot*, 92.

[131] Shaw, *Fighter Combat*, 17.

[132] Tilley, *Fighter Tactics*, 3.

[133] Mahurin, "Major Walker M. Mahurin," 23; Mahurin, *Honest John*, 130. American World War II pilots referred to the surprise attacks as "bounces." See references in *Long Reach*.

expected to remain in position in the "triangular" formations at all times.[134] Now termed "close V" or "four-ship V," or occasionally "fingertip" because the four aircraft in the flight aligned themselves in positions roughly corresponding to the fingertips of an extended hand, American fighter pilots usually flew about 300 feet apart from each other.[135] Responsibilities within the formations likewise mimicked those established decades earlier, although some of the leniency shown by Deullin during attacks had by now disappeared. Younger wingmen were responsible for protecting their more experienced leader's tail while he attacked the enemy. "Stick close to the man you fly with," Mahurin told his pilots. "Watch behind and let him look out in front."[136]

The collective emphasis on surprise "bounces" against an unaware foe, the aerial gunnery tactics, the strict requirement to stay in a V-shaped formation, and even the individual responsibilities within that formation all echoed the themes encountered during the First World War. But there was one significant difference between the two wars: in the First World War the massive, swarming and swirling dogfights that everyone imagined were a rarity; in the Second, and especially after 1943, they were more frequent. For a typical mission, American fighter squadrons in Europe would launch between sixteen and twenty-four fighters, arranged into flights of four. When joined by additional aircraft from the other squadrons in the Fighter Group, massive formations of forty-eight or more fighters would take to the sky, sidling up alongside hundreds of American heavy bombers en route to their continental targets.[137] The *Luftwaffe* fighters below faced a choice: either come up and challenge the fighters in the air or risk getting pummeled on the ground by the bombers.

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[134] Mahurin, *Honest John*, 134–35. On one occasion, Mahurin's flight got separated from the larger group formation and he shot down two aircraft. Still, his commander, Colonel Zemke was livid and threatened to court-martial the young pilot. Fortunately for Mahurin, General Kepner, the commander of Eighth Fighter Command, elected to intervene on his behalf.

[135] McCollom to Commanding Officer, 66th Fighter Wing, "Narrative Report on Bomber Escort by P-47"; Mason to Commanding Officer, 66th Fighter Wing, "352nd Fighter Group Combat Formations"; "Tactics and Techniques of Long-Range Fighter Escort." The Eighth Fighter Command warned that "excessive spreading out of the formation makes it difficult for the leader to maintain control of his squadrons, makes friendly aircraft appear as unidentified aircraft, and subjects individual planes to attack. In addition, excessive power must be used by pilots in order to stay in formation when a turn is made."

[136] Mahurin, "Major Walker M. Mahurin," 24–25. Mahurin offered his assessment of flying in formation: "It is up to the wing man to cover his element leader no matter what. Sure, I know its [*sic*] tough to sit back and tell a guy that he is clear behind so that he can shoot down a Jerry. But," Mahurin lectured, "sooner or later" the wingman would have a chance to become a leader himself, then he would "get the chance to shoot."

[137] "Tactics and Techniques of Long-Range Fighter Escort."

Germany chose the former.[138] Mahurin remembered on one mission spotting "50 to 60 enemy aircraft" approaching the B-17 formations; on another, he encountered "150 enemy fighters."[139] Huge aerial battles ensued. The "gang fighting" of the First World War was alive and well, but now the gangs were veritable armies duking it out in the skies over Europe.

To help the pilots make sense of the increasingly large melees, American fighters came equipped with two new technological tools. One was the aircraft radio. Inability to reliably communicate between aircraft was a frequent complaint of the early flyers. The 1929 text on pursuit flying declared the "lack of adequate communications ... probably the greatest stumbling block in the development of air tactics." While it noted that "neither the radio telephone nor the telegraph can yet be considered entirely satisfactory," by America's entry into the Second World War, the radio was standard equipment in America's newer fighter planes.[140] In theory, the radios allowed the flight leader to coordinate action within his massive formation, but in practice pilots had not yet learned how to use the radio in combat. It was more than just pushing a button and talking into a microphone. With all the aircraft crowded onto a single radio channel and with each pilot thinking he had something important to say, once the battle began, the radio became an incessant chatterbox. The importance of "good R/T [radio-transmitter] discipline" became a recurring theme in World War II tactics reports. One scolded the pilots: "Don't say anything unless it is of importance; don't shout over the R/T, take it calm and easy with proper wording and identification. Many lives will be saved and Huns shot down if the 'babbler' shuts up."[141]

The other tool that the pilots took with them into combat was a gun camera. Built into the front of the aircraft and focused in line with the aircraft's bullet stream, the gun camera automatically snapped images anytime the pilot squeezed the trigger. In theory, the images would provide incontrovertible evidence of enemy downings, eliminating any potential for controversy over aerial victory credits. The grainy images could also be of help

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[138] McFarland and Newton, *To Command the Sky*, 5; Futrell, *Ideas, Concepts, Doctrine, 1907-1960*, 153–54. According to MacFarland and Newton, it was this "symbiotic" combination of bombers delivering strategic attacks and fighters battling for air superiority that allowed the Allies to seize the initiative in the skies over Europe and ensure the success of the Normandy landings

[139] Mahurin, *Honest John*, 132, 136.

[140] *Pursuit Text*, 166–69. The text forewarned of a critical problems pilots would face when using their radios in combat: "Stringent regulations within each flight would be necessary to prevent jamming." See also references in Wentworth, "Lectures by Pursuit Pilots," 4–5.

[141] "We Must Seek out the Hun," 6; Tilley, *Fighter Tactics*, 3–4.

to intelligence officers trying to infer performance data on enemy fighters. And, when they found their way onto newspaper pages or into newsreels, the exciting images provided powerful visual testaments to the superiority of American fighter pilots and their contribution to the war effort.[142] Regrettably, the gun cameras' performance was often suboptimal. It wasn't just that the camera might not run or the film might not turn out, although both were recurring issues. More significantly, the camera could only record images of battle straight ahead. If the pilot maneuvered his aircraft before the enemy fighter started spewing smoke or its pilot bailed out, there might be little visible evidence to support a pilot's victory claim or enthrall the nation. For example, Mahurin said that he lost credit for at least one kill because he "had to pull away" before the camera could "record the last of the bullets striking the enemy aircraft."[143]

The introduction of the gun camera to help substantiate claims was a tangible manifestation of the continued importance ascribed to aerial victories and ace status. Like earlier, these metrics overshadowed all others. Fighter pilots of the Second World War knew that glory could only be earned by downing enemy aircraft, and most preferred air combat to ground attack. As Olds later commented of his World War II experience, "Strafing trains and supply convoys was fine. Bombing the occasional bridge or supply area was necessary. But it was air combat that we wanted. Bombers drop bombs. Fighter pilots fight. It was simply the way it was meant to be."[144] And, like before, when they encountered enemy aircraft, "the business of claims" remained, in Mahurin's opinion, "a funny one. Although our methods of establishing claims were rather stringent, pilots would often imagine that they had seen things that had actually not happened at all.... Heat of combat, excitement, fear and anxiety, all help the imagination along."[145]

The myth of the fighter pilot—a lone individual battling against another in a test of flying skill—also fueled the pilots' imaginations. For the most part, the air combat experience during the two World Wars remained comparable. Pilots still needed to visually detect their enemy. They still needed to possess airmanship so that they could deftly

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[142] For examples of the gun camera footage used in newsreels, see: *Gen. MacArthur Leads Attack on Admiralty Islands*; *Allied Drive on in Italy*.

[143] Mahurin, *Honest John*, 127–29.

[144] Olds, *Fighter Pilot*, 1.

[145] Mahurin, *Honest John*, 128–29.

maneuver their speeding aircraft into position to surprise their foe. And they still needed to be relatively close to their target when they opened fire with their machine guns. Two new technological tools had been introduced, but they had not appreciably affected the conduct of air combat. In the end, the American fighter pilots of the Second World War continued to see themselves as supremely gifted and gallant aerial knights.

The myth of the fighter pilot also continued to stoke the nation's imagination, and as before in the First World War, the fighter pilots became American celebrities out of proportion to their age or military rank. Perhaps telling, when America's leading ace, Major Richard I. Bong, was killed while test flying America's newest jet fighter, the *New York Times* considered the story front-page, above-the-fold, two-column-width worthy news. The date was August 7, 1945. The only headline that received larger typeface that day: the banner which proclaimed, "First Atomic Bomb Dropped on Japan."[146]

Conclusion

Writing of the Union's ironclad *Monitor* in the American Civil War, David Mindell observed that the myth surrounding the machine and its operators far outweighed the combat significance of either. Seen as a great technological advancement, the *Monitor* was in reality a poorly designed floating iron coffin in which the sailors toiled. Hailed as uniquely skilled sailors, without their one-of-a-kind ship, the men of the *Monitor* were likely destined for anonymity. However, when the men and the machine came together in one thunderous but inconclusive battle on March 9, 1862, in the waters of Hampton Roads, they collectively achieved mythical status. Neither could have done so without the other.[147]

So too with the aviators of the First World War. Carefully crafted during the war, the image of the fighter pilot assumed mythological significance, inspiring not only flyers, but also nations and entire segments of Western civilization. But, although the myth of the fighter pilot celebrated the pilot's individuality and his humanity in contrast to the barbarity of mass, mechanistic warfare, the pilot could only achieve this mythical significance when he was attached to his aircraft. This historical contingency was obscured by the nature of the myth.

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[146] "Jet Plane Explosion Kills Major Bong."

[147] Mindell, *War, Technology, and Experience.*

Emerging from the Second World War, the myth of the timeless, naturally gifted fighter pilot, who engaged in chivalric battle reminiscent of the knights of old, was firmly entrenched in the American psyche. A few years later, in the midst of the Korean War, two Air Force recruiting advertisements consciously evoked the image of the iconic fighter pilot mystique. The first, "America's Knights of the Sky," was cited in the previous chapter (figure 1.1). The second invoked the spirit of Rickenbacker's rabble-rousing youth and Guynemer's determination and tenacity. It read: "In the US Air Force, it's not the size of the man in the fight—it's the size of the FIGHT IN THE MAN! ... If you're good enough ... tough enough ... smart enough ... if you can take it while you're learning to dish it out. ... You'll be prepared to fly the latest, hottest planes."[148] In 1951, those "latest, hottest" planes came equipped with a revolutionary new gunsight that promised to dramatically and automatically increase the pilot's lethality. Investigating the new gunsight and the pilots' response to it is the subject of the next chapter.

[148] "It's the Size of the Fight in the Man!," 77. (Suspension points and emphasis in original.)

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Chapter 3

Sabres over Korea: "Every Man a Tiger"

> *It was like money: it did not matter how it had been acquired, but only that it had. That was the final judgment. MIGs were everything. If you had MIGs you were a standard of excellence. The sun shone upon you. The crew chiefs were happy to have you fly their ships. The touring actresses wanted to meet you. You were the center of everything—the praise, the excitement, the enviers. If you did not—although nothing was shameful about it, and there were reasons, allegedly valid, for any man, no matter how capable and courageous, to have failed to get victories—still you were only one of the loose group in the foreground of which the [aces] gleamed. If you did not have MIGs, you were nothing.*
>
> —James Salter, *The Hunters*, 1956

Lieutenant Doug Evans stumbled out the door of his squadron operations building the morning of November 2, 1951. An icy blast greeted him, sucking the air from his lungs. Water welled in his eyes and ran down his nose as he and his flightmates trekked across the tarmac at Kimpo Air Base in South Korea and toward their individual aircraft. They moved "like mummies," he said, stiff from the cold and awkward under the weight of their flying gear. Evans wore a pair of long johns, a wool shirt and trousers, a knit sweater, a wool flying suit, a cashmere scarf, and a leather flying jacket. Somewhere under those layers he also wore his G-suit—which would help keep him from passing out as his blood began to pool in his lower extremities during aggressive, high-G maneuvers.[1] On his feet, Evans wore layers of cotton and wool, flying boots, and rubber galoshes. He also had on his safety and survival gear: the escape and survival vest, complete with hunting knife, signal mirror, extra gloves and socks, first-aid kit, chocolate bars, and an extra signal flare; an orange Mae West inflatable life preserver; his parachute; and a .45 pistol sidearm. Evans opted to wear an ear

[1] In aviation parlance, a "G" refers to one-unit of earth's gravity; hence, a 2G-turn means that that pilot and his aircraft are subjected to an acceleration equivalent to two times earth's gravity.

flap hat and carry his flight helmet—his "brain bucket"—along with his oxygen mask and mission map in one wool-lined-leather-gloved hand; the other lugged an additional heavy survival kit. By the time they got to their assigned aircraft, "we felt like pack mules," Evans recalled, "and it was a relief to get settled down in the cockpit."[2]

But this particular aircraft was different from the others Evans had flown earlier in combat. Trickling into the theater since the summer, this newest model of the Air Force's high-speed, day fighter-interceptor, the E-model of the F-86 Sabre, boasted a revolutionary flight control system compared to its F-86A predecessor.[3] Evans had flown an F-86E a few weeks earlier as part of a familiarization sortie around the airfield. Although he later remarked that he enjoyed the new Sabre's handling characteristics, he remained skeptical of the innovative but "pretty complicated" flight control system and he worried about putting his "fate in the hands of hydraulics without a manual backup."[4]

Evans's assigned F-86E for his November morning mission incorporated another improvement over the more prevalent A-models that populated the flightline. Unsure how to operate the new cockpit device, Evans "called one of the pilots over for a little info on it and he said, 'Just turn on the sight and gun switch. When you get something, the diamonds will snap onto radar ranging to span, a yellow light will come on to show radar lock-on, and

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[2] Evans, *Sabre Jets Over Korea*, 34, 126, 206, 225. Pilots frequently complained about the bulk and weight of their flight gear, but they were also reluctant to forsake any of it lest they got shot down over the mountains of North Korea. See, for example, Mahurin, *Honest John*, 34; Hinton and Wingo, "Analysis of Operations at Kimpo," 3; Hise, "F-86E versus MiG-15 in Korea," 21; Baker, "Report on F-86 Operations," 9.

[3] *T.O. 1F-86E-1*, 1–27–19; Wagner, *North American Sabre*, 54. To improve transonic handling, North American Aviation engineers working on the F-86E elected to discard the F-86A's classic, hydraulically boosted elevator in favor of a solid, controllable horizontal stabilizer, fully powered, along with the ailerons, by a redesigned, irreversible hydraulic system. While the new design allowed the pilot to easily move the flight controls at all airspeeds, it also limited his ability to feel through the control stick the air pressure against the fight control surfaces. To compensate for the loss of the "conventional stick feel," engineers added an "artificial feel system" using "spring bungees."

[4] Evans, *Sabre Jets Over Korea*, 78, 95–96, 198. Evans conceded after his familiarization sortie that the new arrangement "simplifies turns at speed" and rendered "those aileron reversals … just as smooth as you please." Later following a December 1951 mission, Evans recorded in his journal: "I was flying an E model and really appreciated those hydraulic controls as I got that baby going over the Mach." But Evans remained cautious. The next month he noted: "We are still leery of the total hydraulic control system. When one fighter nails another he's usually boresighted right up the butt, and at such low angle-off shoots up the tail first, which in the case of the 86E zaps all the hydraulics that join together there. Then your stick is in cement and you can either bail out or buy the farm.... I, for one, prefer my 86A where I may at least have a chance of manhandling the bird home if badly shot up." For other assessments, see also Jones to Commanding Officer, 4th Fighter Interceptor Wing, "F-86E Combat Evaluation," 2; Mahurin, *Honest John*, 22; Thyng, "Operation of the 4th Fighter Wing in Korea," 3; *Operational Suitability Test of the F-86E*.

you just have to keep the pip on target—nothing to it.""[5] Thus concluded Evans's introduction to the most sophisticated gunsight that had yet been developed for fighter aircraft.

Evans almost scored a victory during the morning's mission using his new A-1C(M) radar-ranged gunsight. He and the other three members of Fox flight arrived in MiG Alley just as a pack of enemy MiGs showed up. Among the "MiG formations scattered all over below us," Evans spied a lone pair of MiGs off to the side. Fox flight dove to attack. "Down the chute we went on those two MiGs—what a beautiful bounce.... Everything was going great. I put the pip on MiG number two and the diamonds opened and closed and then spanned perfectly; that lock-on light sure looked pretty." Just then, the four Sabres came under attack by another formation of MiGs, "diving down like bombs falling right on top of us." The members of Fox flight immediately broke off their attack and turned to defend themselves. After the mission, Evans remarked that they were so close to victory that "we were ready to slap red stars" on our planes. But, he kidded, the MiGs "who jumped us were all ready to stick on white stars. Everybody went to bed hungry, yuk, yuk."[6]

Evans's reference to the red stars that adorned the fuselages of the top American fighter pilots, each star representing an aerial victory, was but one reflection of the continued allure of individual glory that was a critical component of the fighter pilot myth. As the thirty-two year old Air Force Sabre pilot James Horowitz, writing under the *nom de plume* James Salter in his acclaimed novel *The Hunters* noted, "MIGs were everything" to the Sabre pilots. "If you had MIGs you were a standard of excellence." Moreover, "the fifth was more than just another; it was beatification, the step across the gulf."[7] If they wanted to get a kill, and especially if they wanted to become an ace with five, Sabre pilots were told they needed to be aggressive and tenacious like the aces of old. The new pilots that fit the bill were

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[5] Evans, *Sabre Jets Over Korea*, 122. Evans's account contains an inconsistency: in the new A-1C(M) gunsight, the "diamonds" were replaced with a solid, illuminated circle. The diamond-marked reticle from the earlier Mk-18 was reintroduced in the A-4, fielded beginning in late 1952 as a replacement for the A-1C(M), but the timing of Evans's account coincides with the arrival of the A-1C(M), not the A-4. More importantly, his account is reflective of the level of instruction, or lack thereof, that pilots typically received regarding their new gunsights. On the A-4, see "A-4 Sight"; Tucker, "Fire Control."

[6] Evans, *Sabre Jets Over Korea*, 122–23.

[7] Salter, *Hunters*, 62–63; Salter, *Burning the Days*, 153, 163, 196. Horowitz elected to write under the name Salter, a name "as distant as possible from my own," because he considered it "essential not to be identified and jeopardize a career [in the Air Force]—I had heard the sarcastic references to 'God Is My Copilot' Scott."

referred to as "tigers;" those that fell short, "pussycats." The pilots' motto during the war became "Everyman a tiger."[8]

The new A-1C(M) gunsight fielded in the F-86E was designed to help pilots in their quest to prove their worth as "tigers." The radar-ranging gunsight was touted as a revolutionary improvement in fighter aircraft technology. It would simplify the multitude of tasks required of a pilot in the heat of battle, and it promised to extend the lethality of the Sabre's existing armament, allowing pilots to score hits "with extreme accuracy at hitherto impossible ranges."[9] Reports boasted that when used properly, the A-1C(M) doubled the pilot's chances at downing a MiG, instantly turning any junior, mediocre pilot into an expert ace.[10] Following the war, the new gunsight was touted as a critical advantage that enabled the American Sabre pilots to rack up an impressive tally over their MiG-15 foes.[11]

For the majority of pilots seated in the Sabres' cockpits, however, the new gunsight was at best a modest improvement. Many aviators considered the new sight too complex, too heavy, too unreliable, and too impractical for use in the skies over Korea. So unhappy with the new sight, a group of leading Korean aces approached the Chief of Staff of the Air Force (CSAF) in the summer of 1952 and beseeched him to terminate further development of future radar-ranged gunsights. Several argued that the new technology only addressed the final "10%" of a mission. "Approximately 90% of your air-to-air combat is positioning," one Korean ace preached. "If your [*sic*] not in position your [*sic*] not going to get a kill."[12] The gunsight not only did not help with that challenging component of air combat, the ace pilots argued that sight significantly hindered the overall performance of their aircraft, unduly limiting their ability to capitalize on their flying acumen. Capturing the pilots' popular sentiments, the president of the Air Force Association concluded after the war, "In our enthusiasm for the electronic gadgets which take the thrill out of aerial gunnery and grab the

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[8] Blesse, *Check Six*, 58, 60; Mahurin, *Honest John*, 31; Hallion, "Korea: The Forgotten (Air) War," 43. The "everyman" quote is from Lieutenant General William E. Brown Jr., a 125-mission F-86 pilot in Korea, quoted in Hallion. See also references in *Resume of Our Tactics*, 16–17.

[9] "Harmonization and Firing Techniques," 1. There was a pressing need for the improved capability, the manual also noted, because of the "higher speed, greater armor, and increased retaliatory firepower" of enemy aircraft.

[10] *Accelerated Comparison Test*, 1–2.

[11] "Radar Gunsight," 66.

[12] Baker, "Report on F-86 Operations," 6, 11. See also Thyng's similar assessment in Thyng, "Operation of the 4th Fighter Wing in Korea," 7. Blesse likewise noted that "air to air gunnery is only about 10 or 15 percent of the overall problem of destroying an enemy aircraft." Blesse, "Air Tactics Problem," 15.

controls from the pilot, we are inclined to forget that science has yet to produce leadership by remote control."[13]

Thus, in the F-86 example that follows, we see clearly two narratives emerge: one of a "great machine" that boasts of cosmic technologies enlisted to simplify pilots' tasks; the other of a "great pilot" who somehow triumphs in spite of the new and poorly designed machinery. Amidst it all, the myth of the fighter pilot exerted considerable influence over both the engineers' and the pilots' understanding of what air combat was in the past and what it should be in the future. When the engineers tried to codify the public essence of the fighter pilot—his ability to flame an enemy aircraft in glorious battle—they quickly realized that aerial gunnery was not readily reducible to mechanical computations. A certain element of artistry and luck remained. Correspondingly, the pilots in summer 1952 also realized that they could benefit from the new technologies, but only if they surrendered the image of being naturally gifted aviators and instead got their heads into the books to learn the details of the new system. It was this collaboration between the pilots and their gunsight machinery, not the performance of the technology itself, that led to the Air Force's 1952 decision to continue development of its advanced gunsights.

As the first of the three case studies, this chapter establishes the pattern of analysis used to investigate the evolution of the human-machine system as the individual pilot-operators came into contact with their new aircraft fire control systems. For the F-86, I begin by discussing the design and development of the new A-1C(M) radar-ranged gunsight. I then look at the reality of air combat in Korea and its relationship to the still-present and still-powerful myth of the fighter pilot established decades earlier in the First World War. Within this section, I also explore the further institutionalization of the wingman role in the fighter formations as a social element of the human-machine relationship, and specifically the beginning of the transition of the wingman's role from one of tactical necessity to that of a rite of passage for young, aspiring flight pilots. Finally, I explore the controversy that emerged when the new gunsights were confronted with the reality of air combat and individual fighter pilots struggling to use them. In the end, despite the novelty of jet combat

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[13] Stuart, "Salute to Combat Leaders," 24. Stuart drew comfort from recent remarks by the Chief of Air Force Personnel, General Larry Kuter: "Human beings are still the basic substance and most vital element of the Air Force. Their effectiveness, more so than the speed of airplanes or any other factor, will be the ultimate determiner of how much power there is in American airpower."

and the imagery of zooming into battle at closing speeds approaching 1,200 miles per hour, the fighter pilot ace emerged from the Korean War more akin to his goggle-clad, knight-of-the-air predecessors than different, but also with a new appreciation of the importance of advanced fire control technology in an increasingly advanced air combat environment.

A New Solution to an Old Gunnery Problem

As discussed in the prior chapter, the state of aerial gunnery in the Second World War was, like that of its predecessor, dismal. Ace-pilot Walker "Bud" Mahurin writing in late 1943 told his fellow pilots, "If I knew how to practice shooting, I would spend all my waking hours at it." Unfortunately, he didn't, so he primarily concentrated on just getting close enough to his target that he essentially couldn't miss. "If we, and I speak of the Air Forces as a whole, could only shoot perfectly," Mahurin predicted, "we would double our score with no effort at all."[14]

Unbeknownst to Mahurin, Leighton Davis, then a Lieutenant Colonel recently assigned to the Army Air Force's Armament Laboratory at Wright Field in Dayton, Ohio, was working on a potential solution. A 1935 graduate of West Point and an Army pilot, Davis was well aware of the deficiencies in aerial gunnery. During his first assignment in Hawaii flying P-12s and P-26s, Davis had witnessed stray aircraft bullets injure the ground personnel who changed out the gunnery targets between the fighters' passes. After two stints teaching engineering at West Point, with an intervening year spent at MIT earning a master's degree in aeronautical engineering under Professor Stark Draper, Davis was ordered to combat in early 1943. Upon arriving at his new unit, Davis was "amazed" to discover that the aircraft he was being assigned to fly in the Second World War came equipped with the same simple ring-and-bead sight he used in the P-12 almost seven years earlier. Based on his work at MIT with Draper developing a new lead-computing gunsight for the Navy, Davis dashed off a letter to his superiors alerting them to the laggard state of technology in the Army Air Forces' aircraft. Within a few weeks, Davis's flying orders were rescinded and he was told to report instead to Wright Field to begin work on a new gunsight.[15]

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[14] Mahurin, "Major Walker M. Mahurin," 25.

[15] Davis, Oral History Interview, April 26, 1973, 1–14; Wildenberg, "A-1C(M) Gunsight," 30–32. Davis was supposed to begin flying A-36s, a ground-attack version of the famed P-51 Mustang, (although in his 1973 interview, Davis incorrectly referred to the planes as A-31s). Rationalizing the outdated equipment, one Army

When he arrived in Ohio in 1943, Davis immediately understood why development of the Air Forces' gunsights had stalled. "There were two chaps there in the fire control branch," Davis recalled, "and they were optics people," working on "making better lenses for these fixed sights. On the other hand, … there were 150 people working on making the .50 caliber [machine gun] more reliable." The arrangement didn't make much sense to Davis: reliable guns were still worthless guns if the pilot couldn't hit anything. Davis wanted the shop to instead concentrate its efforts on improving the pilot's aim.[16] For his efforts, David would eventually be awarded the Legion of Merit.[17]

The Aerial Gunnery Problem

Shooting down an aircraft with another is difficult. Rarely can the attacking pilot simply point directly at his target; that only works when he is exactly behind the target and at extremely close-range. Rather, the attacker must first adjust his aim to account for gravity's effect on the bullets as they exit the muzzle and travel toward the target, thereby applying a "gravity drop correction." Second, if the enemy aircraft appears to be moving across the horizon relative to the attacker, then the attacker must aim not where the target is but instead where the target will be when his bullets arrive; that angular difference is known as the "lead angle." A third correction, unique to aerial gunnery, is required when the attacking aircraft is maneuvering under higher-than-1G conditions, such as during a level turn. In these instances, a bullet's flight trajectory diverges from the aircraft's longitudinal axis. This "velocity jump effect" causes the bullets to appear to droop away from the gun as they exit the muzzle, similar to that due to gravity, except that the droop is not necessarily in the pure vertical. Additionally, the bullet's flight path may be altered due to a crosswind, or it may be distorted due to vibrations when the gun fires. However, the corrections due to gravity drop, velocity jump, and lead angle tend to be the most significant (and predictable) components when solving the aerial gunnery problem, and of the three, compensation for the lead angle

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representative at a conference on fighter fire control in August 1941 explained that "from 1918 until about two years ago the Army had no funds available for activity in this field." In fact, the Army had made some progress during the interwar years with its N-series reflector gunsights. Nevertheless, the ring-and-bead sight remained a fixture in fighter cockpits because it was durable and inexpensive, important attributes for a cash-strapped air service. See *Control of Plane-to-Plane Fire*; Whistler, "Brief History of USAF Reflector Gunsights."

[16] Davis, Oral History Interview, April 26, 1973, 15–16. Davis complained that the .50-caliber folks "wanted to get that 1,500 rounds per stoppage up to 1,800 rounds per stoppage," a negligible improvement in Davis's opinion.

[17] "Lieutenant General Leighton I. Davis."

due to target motion tends to dominate. Accounting for these three corrections yields the "prediction angle," which is the total angular difference between where the target is and where the guns need to be pointed to score a hit (figure 3.1).[18]

All three primary corrections are significantly affected by the amount of time it takes for the bullet to travel from the attacker to the target. The longer the time the bullet is in the

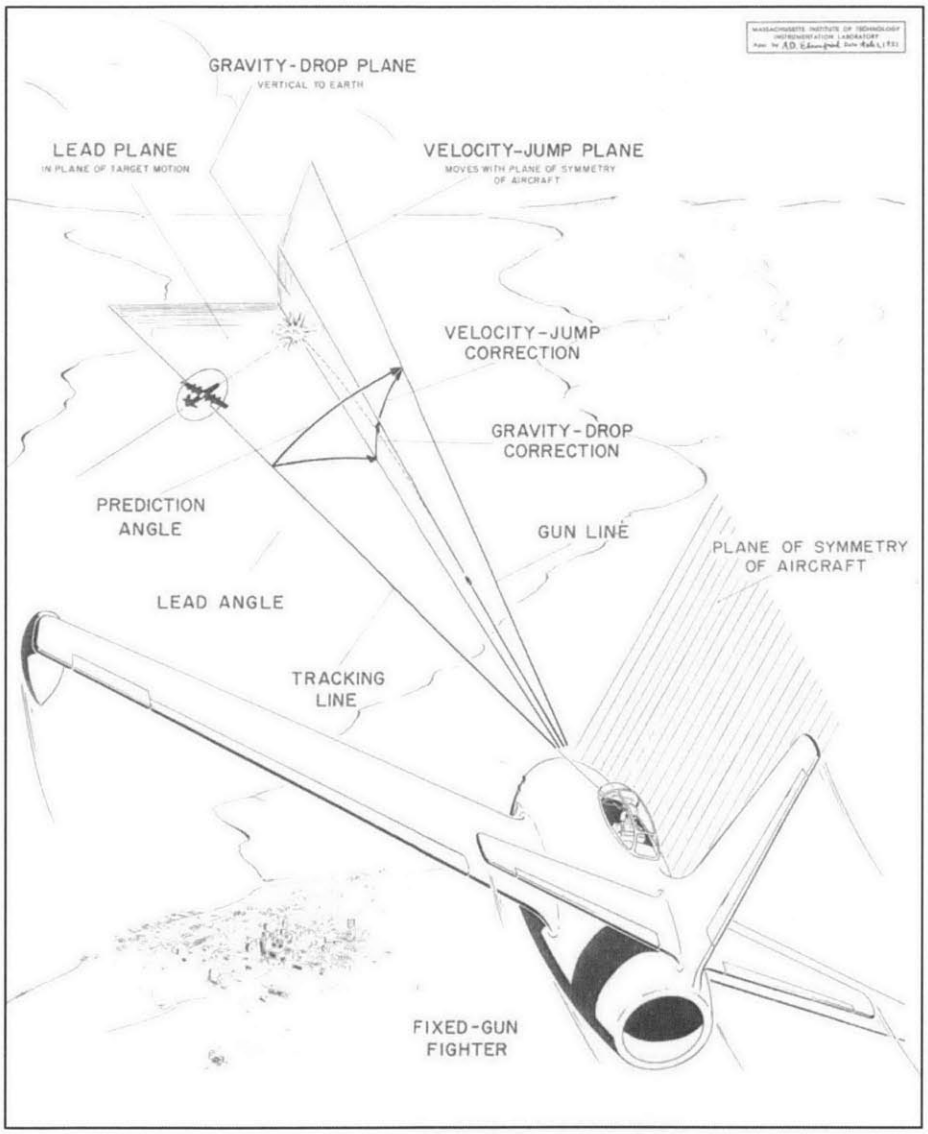

Figure 3.1. Three Critical Components of an Aerial Gunnery Solution.
(Source: Ehrenfried, *General Operating Principles of the A-1*, 4)

[18] On the aerial gunnery problem, see Ehrenfried, *General Operating Principles of the A-1*; *A-1 Sight for the Control of Gunfire*; "Harmonization and Firing Techniques," 2–7; *Type A-1C(M) Gyro Computing Sight*; "Velocity Jump"; Shaw, *Fighter Combat*, 7–10.

air (its time of flight), the more pronounced the effects on the bullet's trajectory due to gravity and velocity jump. The target can travel farther across the horizon, which affects the lead angle. Hence, the bullet's expected time of flight to the target must be known to produce a valid gunnery solution.

The bullet's travel time is itself a function of several factors. Most significant is the range to the target, with longer ranges obviously requiring longer bullet flight times. The density of the air also plays an important role: denser air at lower altitudes and/or higher temperatures tends to slow the bullet, increasing its time of flight. Conversely, bullets tend to travel faster when fired at higher altitudes and/or colder temperatures. The bullet's speed as it exits the muzzle has an understandably significant effect. Although this muzzle velocity is largely fixed by the design of the gun and the round, it can also vary over time due to erosion within the gun barrels, slight variations in the amount of powder packed into each casing, and changes in ambient temperature, which affect the temperature of the powder in the bullet casings. The attacking aircraft's speed also influences the bullet's time of flight since the bullet's velocity through the air is a resultant vector of the muzzle velocity and the aircraft's velocity. So too does the target's velocity relative to the attacker: if the range to the target is increasing because the target is outpacing the attacker, then the bullet will take longer to reach the target.[19]

The net result of all these trajectory and timing corrections and variations is that, even if the attacking aircraft's gun could be aimed perfectly according to a computed prediction angle and fired under the most carefully controlled conditions, it is still highly unlikely that two rounds would ever hit the exact same point in space. This dispersion produces a cone of fire whose diameter expands with increasing range. The dispersion, however, can actually work in favor of the pilot, since it is equally unlikely that any of the bullets he fired would actually hit the precise location he was aiming at. As one gunnery manual noted, "although dispersion may make 100-percent hits impossible, it may raise the actual hits from zero to a useful amount."[20] Thus, while a combination of pilot skill or instincts might get the guns aimed in the correct general vicinity, luck (or the laws of probability) always played a role in actually scoring a hit.

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[19] Ehrenfried, *General Operating Principles of the A-1; A-1 Sight for the Control of Gunfire*; "Harmonization and Firing Techniques," 128–36; *Type A-1C(M) Gyro Computing Sight.*

[20] "Harmonization and Firing Techniques," 129–32.

But even then, finding the appropriate general vicinity to aim could be extremely challenging. It was virtually impossible for a pilot to methodically account for all of the variables, determine the appropriate aiming corrections, position the aircraft properly, and then fire at the correct time. That is why Mahurin and so many others were befuddled by long-range gunnery. It remained part-instinct and part-luck, neither of which were easily reducible to standardized practices that could be readily taught in a classroom or committed to a manual. Mahurin once complained that one of the top gunners in World War II, Jerry Johnson, wouldn't explain the secret of his success; it was more likely that he simply couldn't.[21] Long-range aerial gunnery was an art, and for the majority who were not so gifted, the accepted solution was simply to "fill the windscreen with target and let 'er rip."[22]

Now Davis's team was going to try to transform every fighter pilot into a long-range gunnery expert. Identifying the relevant variables affecting the gunnery problem was only the first step. The engineers still needed to develop a way to measure the variables, determine the appropriate aiming correction, and then display that solution to the pilot. And, because the variables could all change quickly and unexpectedly, the gun solution had to be continuously updated if it was going to be of any use. It was a daunting task. Fortunately for Davis and the others working on the new fighter gunsight, two recent technological developments would aid them: the gyroscopic lead-computing gunsight (LCG) and radar.

New Tools at Hand

The first of the new tools was the gyroscopic lead-computing gunsight (LCG). Davis worked with Draper on an antiaircraft version of an LCG for the Navy during his time in the Instrumentation Laboratory at MIT. The Navy's gunsight was simpler than that required for aerial gunnery, primarily because the sailor shooting from the deck of a ship was not moving and rolling in three axes to the same extent that a pilot would be in an airplane, but both ship-mounted and aircraft-mounted LCGs were based on the same basic principle.

Assuming that the target continues to travel in a straight path at a constant speed, the lead angle component of the gunnery problem is simply a product of the target's angular rate

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[21] Mahurin, "Major Walker M. Mahurin," 25.

[22] Shaw, *Fighter Combat*, 9, 16. Shaw, a veteran Navy pilot, summed up the aerial gunnery problem: "Given all the forgoing factors that come into play, it's amazing that an air-to-air gun kill is ever recorded.... Little wonder the most effective technique is often to 'fill the windscreen with target and let 'er rip.'"

(relative to the gunner) and the time of flight of the bullet.[23] For example, a distant aircraft traveling across the horizon would have a lower angular rate than a nearer aircraft traveling on a parallel flight path at the same airspeed. But, because the bullet would take longer to travel to the more distant aircraft, the required lead angle may be similar to or greater than that of the nearer aircraft with a higher apparent angular rate. Knowing that the correction for lead angle dominated the gunnery solution, Draper's team focused on measuring these two variables—angular rate and range to the target—and transforming them into a reliable and intuitive method of directing a sailor's aim.

Their ensuing Mark 14 gunsight, produced by Sperry Gyroscope Company, found widespread use during the Second World War. The gunsight could be affixed to any 20-mm gun emplacement located on a Navy ship. Standing behind the guns and looking through the gunsight's window, the sailor-gunner would see an illuminated reticle appear to hover within his viewing frame. Inside the gunsight were two single-axis gyroscopes, one mounted in the horizontal plane, the other mounted ninety-degrees perpendicular in the vertical plane. When the sailor-gunner swung his antiaircraft guns left or right and/or up or down, the spinning gyroscopes detected the movement. If the sailor-gunner were to smoothly follow a target with his guns, adjusting them in both elevation and horizontal deflection to keep the reticle in the gunsight's window superimposed over the target—a process known as tracking—the total angular rate of the target could therefore be measured. Once supplied with an estimate of the target's range (described in more detail below), the gunsight could then mechanically compute the necessary lead angle. Draper's team decided that the best way to communicate this solution to the sailor-gunner was to adjust the position of the reticle in the gunsight's window. The sailor-gunner simply needed to keep the moving reticle superimposed over his moving target.[24]

To understand how the system worked in practice, imagine a gunner looking through the window of his gunsight, which is mounted on his guns. He sees a target moving level across the horizon, left-to-right. The gunner initially turns the guns to place the reticle over the target. Because the target is moving left-to-right, the gunner must then rotate his guns to the right to keep the gunsight's reticle over the target. Inside the gunsight, the gyroscopes

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[23] Davis, Oral History Interview, April 26, 1973, 10–12.

[24] Mindell, *Between Human and Machine*, 220–23; *Gun Sight: Mark 14*.

measure how fast the guns are rotating. Using a provided range estimate, the gunsight computes the necessary lead angle. The gunner looking through the gunsight then sees the reticle start to drift to the left, behind the target. He adjusts the rate at which he is rotating the guns to re-center the reticle on the target, after which the reticle appears to stabilize in position within the gunsight's window.[25] With the reticle now closer to the left side of the gunsight window but once again superimposed over the target, the gunner resumes rotating the guns at a rate commensurate with the target's motion over the horizon. The net effect is that now the guns have been aimed in front of the target at the necessary lead angle, but for the sailor-gunner looking through the gunsight, he simply continues to see the reticle superimposed over the target (figure 3.2).

As one Navy manual explained the process to its gunners, "Remember, you're working with a LEAD-COMPUTING GUN SIGHT. This means that when you have your target framed in the reticle and are tracking smoothly, your gun is being aimed ahead of the target AUTOMATICALLY.... Don't lead with the reticle. Do keep the reticle on the target. Let your sight work FOR you!"[26]

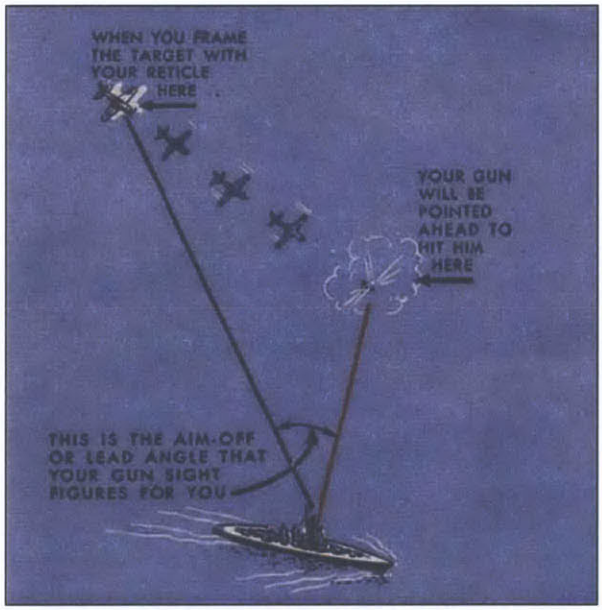

Figure 3.2. Mark 14 Antiaircraft Gunsight.
(Source: *Gun Sight: Mark 14*, 8)

While the gunsight's gyroscopes could automatically measure angular rate as the gunner tracked the target, it needed an operator to manually input the target's range. Normally, a sailor-gunner was paired with a "range setter" to accomplish this task.[27] The range setter would estimate the range to the target and then adjust the Mark 14's range knob, located on its right side, accordingly. However, with the range setter visually estimating the distance to the target, and with the

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[25] As will be explained in more detail later, dampers attached to each gyroscope limited the effect of these abrupt movements, smoothing the commanded lead angle over time.

[26] *Gun Sight: Mark 14*. Emphasis in original.

[27] Ibid., 11. Inputting the range into the Mark 14 was only one of the range setter's responsibilities. According to the manual: "The Range Setter sets the range on the Sight, watches for targets, helps the gunner locate the targets, and watches so the other half of the team doesn't fire at friendly ships and planes."

Mark 14's range knob only adjustable in 400-yard increments, there was little chance the ranging would be accurate. It didn't necessarily matter, though, because the range setter could just adjust the range based on the observed path of the tracer bullets. For example, if the tracers were tracking well in front of the target, and assuming the gunner had announced that he had the target under the reticle, then the range setter would know to dial back the range knob. But, for the gunner trying to figure out the target's range so that he knew when to open fire, there was no source of range information; he was told to simply compare the target's size to the fixed size of the gunsight's aiming reticle and guess.[28]

While not perfect, the Navy's Mark 14 possessed the "right combination of precision, ease of use, and simplicity" needed to outfit the thousands of guns adorning the decks of Navy ships. Boasting of the Mark 14's capability, Sperry's president, Tom Morgan, wrote in 1945, "The new sight broadens the mental powers of the gunner, frees him from tasks requiring judgment, and enables him to devote his entire attention to accurate 'tracking' of enemy aircraft." One Navy officer who oversaw the Mark 14 project proclaimed that the gunsight offered "fire control for the masses."[29] The reputation of the new sight was sealed when Mark 14-equipped gunners aboard the USS *South Dakota* reportedly downed thirty-two Japanese aircraft during the Battle of Santa Cruz on October 26, 1942.[30]

The immediate success of Draper's Mark 14 gunsight aboard Navy ships renewed the Army's interest in LCGs for use in its aircraft. Earlier while he was still at MIT, Davis had been unable to convince the air ordnance officers overseeing the Army's gunsight development of the feasibility of Draper's solution. However, in March 1942, just as the Mark 14s started to emerge from Sperry's workshops, the director of the Office of Scientific Research and Development, Vannevar Bush, sent a memo to General Carl Spaatz, then serving as chief of the Army Air Force Combat Command in Washington, DC, alerting him to the recent developments in "the gyro-type of lead computing sight." Bush was

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[28] *Gun Sight: Mark 14*; Mindell, *Between Human and Machine*, 221. In the instance that the target was attacking the ship, the range would be collapsing so fast that the operator's manual recommended setting the range knob at 800 or 1,200 yards and leaving it alone. Plus in this situation, errors in the calculated lead angle due to the erroneous range input would naturally decrease as the target got closer.

[29] Quoted in Mindell, *Between Human and Machine*, 221. The Navy initially purchased 2,500 Mark 14 sights in mid-1941; by 1945, the service had more than 13,000. *Antiaircraft Action Summary*, 12.

[30] "Navy Identifies Battleship 'X.'" At the time, the *South Dakota* was referred to in the press as Battleship X. After the war, the Navy figured that "guns controlled by [the Mark 14] shot down more aircraft than any other." *Antiaircraft Action Summary*, 12.

enthusiastic in the memo, telling Spaatz, "I think, personally, that it has much application, and I hope that our people will have the best thing possible when they are called on to use it."[31]

Unfortunately, the Army's subsequent attempts to develop an LCG for aircraft use floundered. So too did the Navy's for their aircraft.[32] Consequently, both services elected to copy a British design: the Army called their version the K-14; the Navy designated theirs the Mark (Mk-) 18.[33] Both were not fielded until late in the war, and both would continue to see service in the immediate post-war years. In fact, Air Force officials elected in 1949 to use the Navy's Mk-18 gunsight in their new F-86A Sabres then rolling off assembly lines.[34]

Despite using only a single gyroscope, the K-14 and Mk-18 gunsights were functionally similar to Draper's Mark 14 two-gyroscope design. Because the single gyroscope was allowed to precess in both elevation and deflection, it could measure the total angular rate of the target relative to the attacking aircraft. Then, with an estimate of range, the gunsight could mechanically compute the appropriate prediction angle and adjust the optical aiming reticle to show the attacker where to point his aircraft in order to aim his guns and score a hit.[35] Like the sailors using Draper's Mark 14, pilots using the K-14 or Mk-18 simply needed to place the aiming reticle over the target, track it for a second, and then shoot.

The pilots, however, had to complete one additional task. Whereas the sailor using the Mark 14 usually had an assistant nearby to visually estimate the target's range and then

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[31] Davis, Oral History Interview, April 26, 1973, 12–13; Bush to Spaatz, March 11, 1942.

[32] Werrell, *Sabres Over MIG Alley*, 27; Boyce, *New Weapons for Air Warfare*, 58–59; *Control of Plane-to-Plane Fire*; *Conference on Plane-to-Plane Fire Control*; Davis to Chief, Armament Laboratory, "Aircraft Sights." Writing after the war of OSRD's efforts, Boyce noted that "under the stress of war the versatility of the fighter plane had flourished, but instrumental aids to the pilot were virtually nonexistent. The problem of rendering help in this situation was especially difficult because of the stringent requirement that the sight had to *help* the pilot, and not give him so much of a task of sight manipulation that he couldn't fly his plane" (emphasis in original). OSRD did not begin "its program of development in this area" until early 1944.

[33] Werrell, *Sabres Over MIG Alley*, 27. Britain had begun working on LCGs for aircraft use in 1939, part of its frantic attempts to bolster its fighter defenses in the build-up to World War II.

[34] Ibid., 10, 14, 27. Werrell noted, "There is no explanation why [the USAAF] picked the navy gunsight over its AAF sibling, the K-14," for the new F-86. The first flight of the F-86 (then designated the XP-86) was October 1, 1947. Rickenbacker's old squadron, the 94th Hat-in-the-Ring, was the first squadron to receive the new fighter in February 1949.

[35] "Harmonization and Firing Techniques," 31–37. In the K-14, the range to the target was used to electromagnetically control the amount of gyroscopic precession in the gunsight, thereby limiting the movement of the aiming reticle. As one manual described the process, "If the range to the target is small, the magnetic forces caused by the range current are strong, and the turning rate of the aircraft can move the gyro through only a small angle. If the range to the target is large, the magnetic forces caused by the range current are weak, and the turning rate of the aircraft can move the gyro through a larger angle."

feed that information into the gunsight, the pilot in a single-seat fighter needed to perform that task himself. Moreover, his gunsight demanded a more refined estimate of range to accurately compute the gunnery solution. The method the pilot used to determine the target's distance, known as *stadiametric ranging*, was not new. It is based on the trigonometric relationship between similar triangles which allows an observer to estimate the distance of one object by comparing it to a different object of known size and known distance. It was also the same method used decades earlier when World War I pilots carved notches onto the top of their fuselage to serve as a "crude but effective range finder."[36] And, it was the same principle used by the sailor-gunner who decided to open fire based on the relative size of his target compared to the size of his aiming reticle. But in the K-14 and the Mk-18, the stadiametric ranging process was mechanized to automatically feed the target range information into the gunsight for use in its calculations.

Focusing discussion on the operation of the Mk-18 because it equipped the first F-86A's used in Korea, the pilot first set the "span scale selector lever," located on the front of the sight unit, to the wingspan dimension of his anticipated foe (figure 3.3). Then, once the pilot found his adversary and maneuvered into a position near its six o'clock, he adjusted the size of the Mark 18's "gyro reticle circle," outlined by six illuminated diamonds and projected in front of him, to visibly span the target's wingspan (the target dimension entered using the span scale selector lever) (figure 3.4). To make the gyro reticle larger, corresponding to a shorter range to the target, the pilot twisted his throttle control clockwise; conversely, twisting the throttle control counterclockwise reduced the reticle size. The Mk-18 compared the size of the pilot-spanned gyro reticle circle with the dimension entered using the span selector lever, mechanically computed the target range, and then used that information to update the commanded, displayed prediction angle. The Mk-18 also retained the option of displaying a fixed aiming reference in addition to the computed, prediction angle-positioned reticle.[37]

Hence, operating the Mark 18 sight was simple in principle, reduced to only three steps in the F-86A pilot's manual:

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[36] *Pursuit Text*, 164. More formally, stadiamteric ranging is based on the principle that one miliradian (mil) approximately subtends a length of one foot at a distance of 1,000 feet.

[37] *T.O. 1F-86A-1*, 4–18–19; "Harmonization and Firing Techniques," 31–37; "Gun Sight: Mark 18"; Wagner, *North American Sabre*, 25; Werrell, *Sabres Over MIG Alley*, 26.

1. Identify target; then set span scale selector lever to correspond with span of target airplane.

2. Fly airplane so that target appears within gyro reticle circle, and rotate range control until the diameter of the gyro reticle circle corresponds to size of target.

3. Keep target with gyro reticle circle by rotating range control as range changes. Track target for one second; then fire.[38]

The third step in the Sabre's flight manual, however, hinted at the difficulties a pilot might experience when trying to use the Mark 18 in practice. Air combat was not a static exercise. Rarely would the attacking aircraft be able to assume a perfectly stabilized position at a constant range behind the target. This meant that the attacking pilot needed to constantly twist the throttle control lever, adjusting the reticle size to account for changing target distance. Also, rarely could an attacking pilot maneuver to the direct six o'clock position behind his target, which meant that the attacker's viewing perspective of the critical target dimension that he was supposed to span with the reticle (usually wingspan) was often distorted or obscured, a problem known as *foreshortening*.[39] Finally, rarely would the target aircraft remain non-maneuvering when under attack. Any aggressive

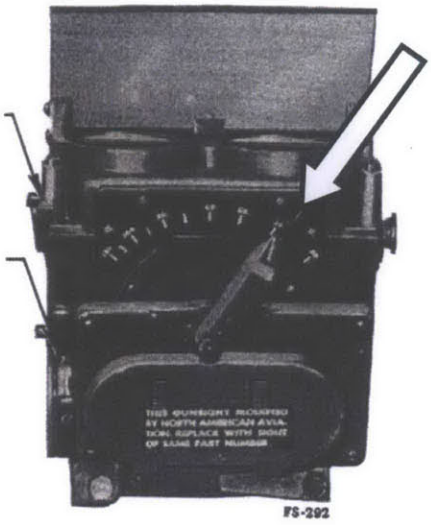

Figure 3.3. Mark 18 Gunsight, Span Selector Lever.
(Source: *T.O. 1F-86A-1*, 4-19)

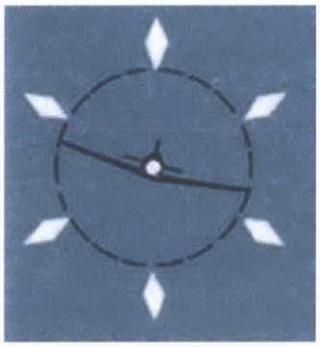

Figure 3.4. Aiming Reticle, Mark 18 Gunsight.
The reticle consisted of the central aiming pipper (or pip) and the set of six diamonds that the pilot sized around the target. The dashed circle was not visible.
(Source: *Gun Sight, Mark 18*)

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[38] *T.O. 1F-86A-1*, 4–19. The three-step procedure was accompanied by five additional "operational notes," the first three of which concerned the use of the sight in combat: "1. Keep sight operating whenever its use is probable. 2. When maneuvering into position for attack, keep sight set at shortest range (large-diameter gyro reticle image circle) and decrease diameter to correspond to size of target. 3. Always track target before firing. By operating ranging control, continually frame the target while tracking for a minimum period of one second; then fire. Only after such tracking will the lead be correctly compensated."

[39] Mitchell, "Airborne Fire Control," App 205. Mitchell descried the requirement to know "the size and angle off of the target" as "an obvious disadvantage" of stadiametric ranging. One group of Air Force officers suggested that the foreshortening issue could be reduced if the gunsight and reticle were recalibrated to span the target fuselage instead of the wingspan. Their recommendation was never adopted. "Bailey Pipper."

maneuvers by the target, in addition to altering the closure rates and distorting the attacker's perspective of the critical target dimension, required the attacking pilot to focus on following the target and keeping it under the shifting reticle as the Mark 18 computed new prediction angles.[40]

In sum, to use the Mark 18 gunsight, the pilot needed to maneuver his aircraft in three dimensions to position a target, also moving in three dimensions, under a reticle that was moving in two dimensions and that had to be constantly resized to a dimension that was not always visible. Evans later admitted of his time spent using the Mk-18 that the process of "trying to do everything at once" could quickly become overwhelming.[41] One Air Force study noted that imprecision in the stadiametric ranging process produced average errors of 22 percent of the distance to the target. Under these less than ideal circumstances, the effective range of the gunsight with .50-caliber ammunition was no more than 1,000 feet.[42] Still, despite the difficulties associated with operating the manual ranging system, the new aircraft LCGs used late in the Second World War yielded a five-fold increase in hits and a three-fold increase in kills.[43]

One MIT engineer would later describe the problem of "ranging" as "the bugaboo of aerial gunnery."[44] To address the obvious shortcoming of the current system, Davis's and Draper's team working on the new gunsight turned to another innovation coming to life on MIT's campus—airborne radar. Ever since the delegates of the British Tizard mission unveiled the resonant cavity magnetron to a group of astonished American military and scientific leaders in late summer 1940, the American scientific establishment, and particularly those at the MIT's Rad Lab, had been furiously developing a plethora of short-wavelength radar-based gadgets for the US military. Initially, the Rad Lab's top wartime priority—

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[40] Recognizing its limitations, designers allowed the pilot to toggle between the lead-computed reticle and a fixed aiming cross. The pilot could even select both to be displayed at the same time, providing a clear visual indication of the prediction angle computed by the gunsight. "Gun Sight: Mark 18." See also Jenkins, "Some Notes."

[41] Evans, *Sabre Jets Over Korea*, 85, 182. Describing one engagement in which he "made a head-on" pass against a MiG, Evans remarked, "What a closure rate! Just too fast for a calm range estimation peering through a gun sight."

[42] *Accelerated Comparison Test*, Inclosure 2:3; "Harmonization and Firing Techniques," 31, 129.

[43] Werrell, *Sabres Over MIG Alley*, 27. Werrell concluded, "One reason for this success was that the sight achieved hits at greater ranges (as far as six hundred yards) and deflection angles (some over 50 degrees) than the older sight. The computing sight made average and inexperienced pilots good shots, especially when deflection was needed, whereas only a few pilots were able to master the older equipment."

[44] Greene to Commanding General, Continental Air Command, January 31, 1950.

Project I—was to develop a 10-cm wavelength radar that could detect an aircraft but was also compact enough to be housed in a medium-size bomber. The Rad Lab scientists and engineers originally hoped to have their airborne interceptor (AI) radar project completed by early March 1941. They came close, outfitting a B-18 with an AI radar for a first flight on March 10. Although the first mission produced "poor results," performance steadily improved.[45]

The first AI radar sets were heavy, bulky contraptions that could only be carried in large, multi-crew, multi-engine aircraft. For example, although much-improved over its predecessors, the SCR-720 radar in the P-61 Black Widow, fielded in early 1944, weighed more than 400 pounds and required a dedicated crewmember to operate it. Its operation reflected the basic radar principles that would guide all future radar designs. The radar transmitter inside the aircraft generated short, intense bursts of energy and fed them to the radar antenna. Mounted on powered gimbals at the front of the aircraft that spun and rotated the antenna in a spiral pattern, the radar energy was focused into a narrow beam and transmitted out into the atmosphere. A timer or synchronizer in the radar set regularly interspersed the brief radar transmissions with long periods dedicated to receiving any reflected radar energy. Measuring the time between when a radar pulse was transmitted and when any reflected radar energy was received yielded the range to the target, which was displayed to the operator on a cathode ray tube (CRT). To determine the relative bearing to the radar target, the radar set would note the position of the antenna in its spiral pattern when the reflected energy was received. That relative position was also displayed to the operator on a second CRT.[46]

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[45] Gurelac, *Radar in World War II*, 253–65, 271–73; Buderi, *Invention That Changed the World*, 27–28, 33, 37, 43, 46, 51, 70–71; Bowen, "Tizard Mission." Bowen later described his secret parcel as "a gift from the gods" for the Americans. Initially designated the Microwave Laboratory, the facility/organization at MIT was quickly renamed the Radiation Lab "because it concealed, yet in ironical fashion expressed, the field of activity." The new name suggested that MIT was pursuing the same "esoteric" nuclear research as being conducted at Berkeley. On Britain's earlier attempts at developing AI radars for its nightfighter aircraft, see Gurelac, *Radar in World War II*, 145–52, 159–64. On the magnetron in airborne radar, see Ibid., 185–87, 224–31; Stimson, *Introduction to Airborne Radar*, 18–19.

[46] Blake to McCormick, "Request for Communication and Electronic Equipment Data," Inclosure 4; McFarland, *Conquering the Night*, 7–12; Skolnik, "Fifty Years of Radar," 184; "Harmonization and Firing Techniques," 40–41. For more information on airborne radar principles, see Stimson, *Introduction to Airborne Radar*; Gurelac, *Radar in World War II*, chap. 2.

While useful in the P-61, the arrangement was obviously ill-suited for use in a small, single-seat fighter, and the military continued to search for alternative designs.[47] The Army Air Force's landmark, multi-volume, post-war study, *Toward New Horizons*, published iteratively between 1945 and 1946, made mention of the lingering requirement:

> It has been found that the most successful day-fighter pilots are those who can judge the range to the enemy most accurately and who hold fire until the range has closed to an effective firing value. This range data can be supplied for the pilot simply and automatically by a lightweight radar, which can be used to light a green light when it is time to fire. New, fast planes, such as the P-80, will particularly need this facility, for the firing time in an encounter may be short indeed.[48]

The Army Air Forces' newest gunsight capitalized on these advancements made in LCGs and radar technology that occurred near the end of the war. As one manual described the situation, "Further development and improvement of the K-14 gunsight and far reaching advances in the field of radar resulted in a gunsight almost completely automatic in its operation." The new A-1 gunsight finally offered a viable solution to the air gunnery problem. It was, the manual declared, "the most versatile fighter type sight in operation."[49]

The A-1C(M) Gunsight

It took Davis nearly two years, but on March 26, 1945, his efforts finally culminated in an Army Air Forces contract with MIT and Draper's Instrumentation Laboratory for a "Computing Combination Bomb Sight and Gun Sight."[50] While work on the new sight had begun earlier in November 1943 as part of Army Project MX-402, it would take another three years after the contract was signed before the sights were considered ready for installation in the newest service's newest fighters (the Air Force became an independent

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[47] *Test of A-13B Ball Turret*, 3; Bloss to Commanding Generals, "Status of Development"; Gurelac, *Radar in World War II*, 329–32. For example, after testing the AN/APG-5 radar in an A-13B ball turret, a 1946 report recommended that "every effort should be made to further develop the APG-5 or a lightweight modified automatic radar ranging unit for all gun sights." Bloss's 1947 memorandum noted that Air Defense Command still maintained "a high priority requirement for a lightweight radar gunsight for the penetration fighter."

[48] DuBridge et al., *Radar and Communications*, 11:22.

[49] *A-1 Series Sight*, 2.

[50] "Fixed Price Contract." Even by October 1944, Davis was still encountering resistance to developing more advanced LCGs for Army aircraft. In one memorandum, Davis questioned his superiors on why the service was continuing to buy "outmoded [gunsight] systems for applications where dynamic performance is the criteria. One thing we <u>are</u> sure of is that the airplane is not going to stop and let us compute the problem on a static or even on a 'steady state' basis." Davis to Chief, Armament Laboratory, "Aircraft Sights," 4.

branch of the military in September 1947). As work on the sight was progressing, Draper in 1946 offered a rather understated appraisal of the project: "The A-1 Sight offers a form of fire control equipment that should produce operationally worth-while results in fixed-gun fighter installations."[51]

The A-1C(M) installed in the F-86Es that began arriving in Korea in summer 1951 represented the third iteration of Draper's new aircraft gunsight (figure 3.5).[52] The A-1B version of the sight was installed in some F-84 Thunderjets and a handful of early F-86 Sabres beginning in March 1948. However, flight tests later that year revealed significant

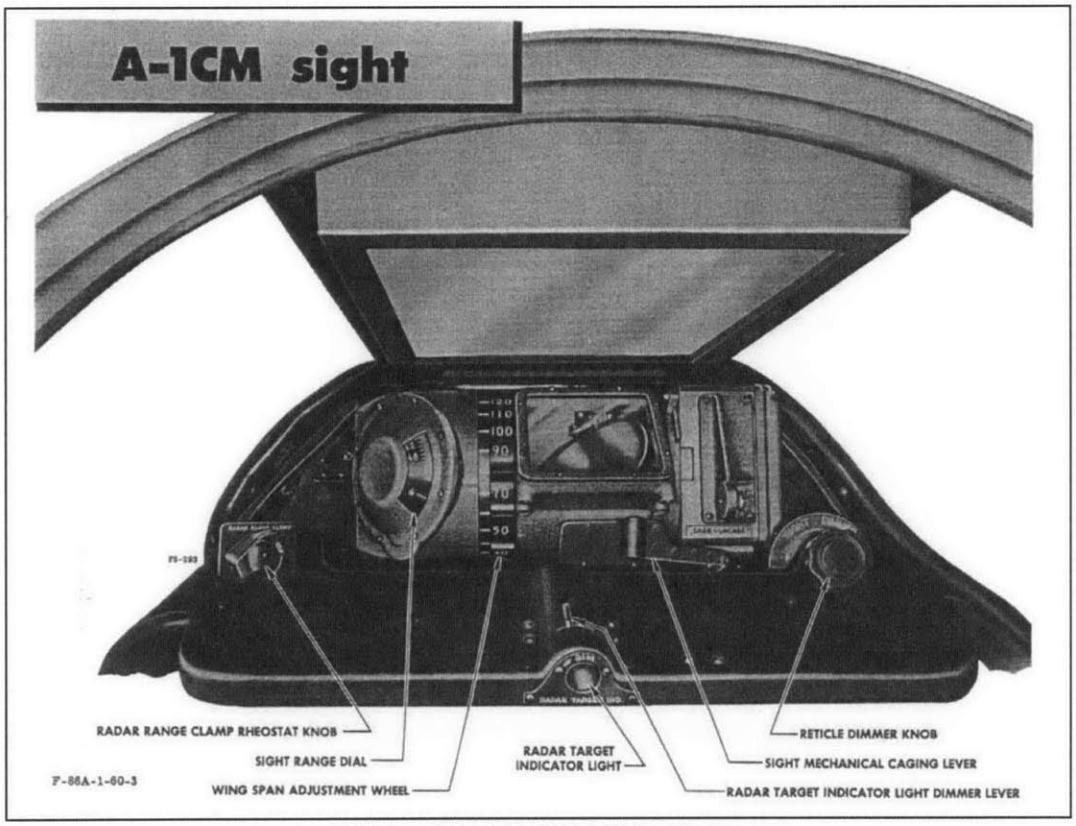

Figure 3.5. A-1C(M) Sight Unit.
(Source: *T.O. 1F-86A-1*, 4-20)

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[51] "Fixed Price Contract"; *A-1 Sight for the Control of Gunfire*, i–vi; *A-1 Series Sight*, 2; Davis to Chief, Armament Laboratory, "Aircraft Sights"; Wildenberg, "A-1C(M) Gunsight," 33.

[52] "Standard Aircraft Characteristics: F-86A," December 8, 1950, 3; "Standard Aircraft Characteristics: F-86A," September 21, 1951, 3; "Standard Aircraft Characteristics: F-86E," 3; Werrell, *Sabres Over MIG Alley*, 23–24, 27–28. The A-1C(M) was first mass-installed in the F-84E. In addition to coming factory-installed in the F-86E, the last twenty-four F-86As that rolled off the production line were also equipped with the A-1C(M). Earlier produced A-models were eventually retrofitted with the A-1C(M) and AN/APG-30. The radar range clamp rheostat in Figure 3.5 was part of the Jenkins range limiter improvement to the A-1C(M), discussed later in this chapter.

problems with the new sight and its tendency to display "reticle jitter" when the aircraft guns were fired, transforming the precise illuminated aiming sight into just "an orange blur." Sperry Gyroscope and the AC Spark Plug Company, which had received the production contract for the A-1 sights, tried to correct the jitter problem by adding new "stainless steel stiffeners" to the sight, yielding the A-1C in April 1949. However, the Air Force demanded that the two firms continue to work on improving the sight's usability in the field. The resulting, newly modified sight, now referred to as the A-1C(M), boasted "a more efficient sight head and computer heating system, a brighter reticle, and special stiffeners to reduce reticle vibrations."[53] While all three versions of the A-1 possessed the capability to direct gunfire, rocketfire, and bomb delivery, I focus exclusively on their gunfire function because that was the only mode used by the majority of F-86E pilots during the Korean War.

Like Draper's earlier Mark 14 gunsight, the dual gyroscopes in the A-1 measured changes in elevation and deflection. When provided with the target range, the mechanical computer calculated the appropriate prediction angle and displayed the solution to the pilot through a separate sight unit. If the pilot maneuvered his aircraft "correctly and smoothly" so that the illuminated reticle was "continuously superimposed on the target under attack," and if he maintained this "tracking" position for approximately one second before firing his guns, then his aircraft, the A-1 manuals noted, would "approach a position from which its projectiles will strike the target."[54]

Whereas the effectiveness of the Mk-18 was limited to 1,000 feet range, the extra precision of the A-1C(M) increased the effective firing range of the same .50-caliber armament to nearly 3,000 feet.[55] A good portion of that improvement could be traced to the A-1's new source of range data. Rather than relying on pilot-provided estimates of target range obtained through stadiametric ranging, a radar mounted in the fighter aircraft now "automatically and continuously" fed precise range data to the gunsight. Although technically not one of the nine components that comprised the A-1 gunsight system, the radar was nonetheless critical to the gunsight's operation.[56]

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[53] Wildenberg, "A-1C(M) Gunsight," 33–34; Bloss to Commanding Generals, "Status of Development."

[54] *A-1 Series Sight*, 2–3; Ehrenfried, *General Operating Principles of the A-1*, 1; *A-1 Sight for the Control of Gunfire*, 1, 5–6.

[55] "Harmonization and Firing Techniques," 12, 31.

[56] *A-1 Series Sight*, 25; Ehrenfried, *General Operating Principles of the A-1*, 3; "Harmonization and Firing Techniques," 18. The nine components of the A-1C(M) were the amplifier, range servo, rocket setting unit,

General Electric's APG-30 radar was the radar of choice for the A-1C(M).[57] It was a relatively simple set compared to the larger AI systems used in earlier aircraft like the P-61. It had no CRT display for the pilot and provided no information on target location or relative bearing. The APG-30 radar simply measured range to a target. Its advantage, however, was that it could fit in the tiny F-86, the radar's small antenna housed behind the pouting upper lip of the Sabre's intake (figure 3.6).[58] Like its gunsight counterpart, the APG-30 was designed to function with very little input from the pilot. The pilot simply turned the unit on and, after a ten to fifteen-minute warm-up period, the radar began automatically transmitting its 9.3 GHz waveform at 800 pulses per second. The APG-30 was advertised to be effective out to ranges of 9,000 feet. If any object was detected within the antenna's fixed eighteen-degree beamwidth, the APG-30 would

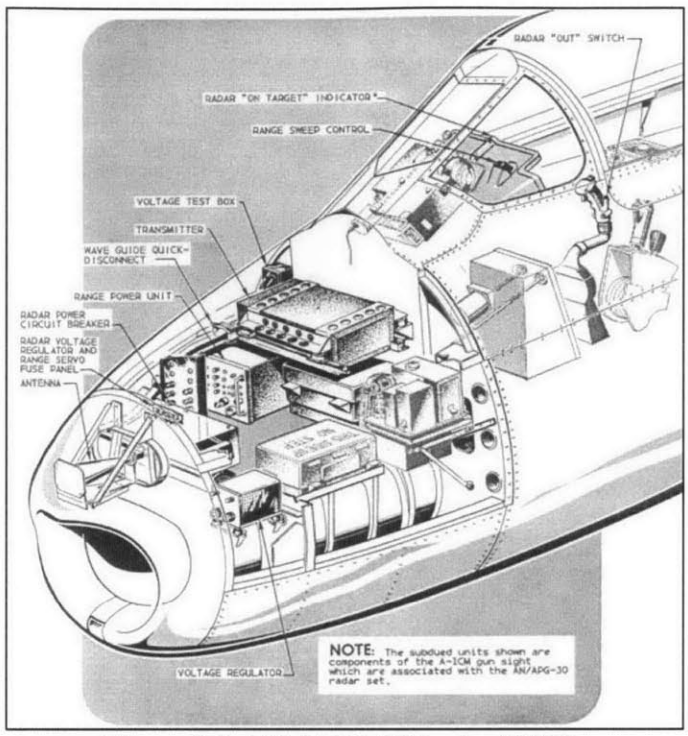

Figure 3.6. AN/APG-30 in the F-86E.
(Source: *T.O. 1F-86E-2*, 435)

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sight head, dimmer control, manual range control, bomb target unit, and computer. The decision to not include the radar in the A-1 system reflected the Air Force's desire that the A-1 be universal, capable of working with any radar. However, this arrangement also meant that no one entity coordinated development of the total fire control system, which directly contributed to significant problems with the system's reliability and maintainability. Years later, the Air Force would finally link the two components together under a new J-series Fire Control System designation: J-1 to designate the A-1C(M) and APG-30 combination, J-2 to designate the new A-4 sight and APG-30 radar. See also *Accelerated Comparison Test*, Inclosure 1, 1; Futrell, *USAF Operations in the Korean Conflict, 1 Jul 1952 - 27 Jul 1953*, 65; Long, *USAF Fighter Aircraft Fire Control Systems.*

[57] Wildenberg, "A-1C(M) Gunsight," 34; Bloss to Commanding Generals, "Status of Development"; *Automatic Range-Only Radar.* The AN/APG-30 was designed specifically for fighter aircraft and the A-1 gunsight. Prior to APG-30 production, some early A-1B sights were paired with the AN/APG-5 radar, originally designed for use in B-17 and B-24 gun turrets.

[58] Campion, "But Why Are We Losing." Installing a radar in the nose of a high speed fighter proved challenging in its own right. The radar needed to be covered by a "nonmetallic material" that would "not interfere" with its operation. Initially, engineers at North American tried a "lacquered glass covering," but they soon discovered that when an F-86 flying at 650 miles per hour encountered rain, the covering "wore away." A "makeshift covering" was developed using "keg-liner, the material used to line the inside of beer cans," before a neoprene radome was introduced as a "more permanent solution."

automatically lock on and a single "tracking indicator" would illuminate in the cockpit. A range dial on the A-1's sight unit also provided indication of a lock on when it quickly rotated to indicate the radar-measured range to the target, displayed in hundreds of feet.[59]

There were issues with the radar's automaticity, however. Most significantly, if there were multiple targets in front of the aircraft and within the radar's field of view (including large non-aircraft radar targets such as mountains), the radar would simply lock on to the first target it detected. There was no way for the pilot to know what the radar decided to track. To verify the radar's target selection, the flight manual suggested the pilot "check [the] range dial indication against [the] estimated range of target." If the pilot still remained unsure, or if he determined that the radar was not locked to the desired target, then the manual instructed him to depress the "Range Gate Out" switch (sometimes referred to as the radar target selector button) on his control stick to interrupt the tracking. The radar would then break lock, return to search, and lock the next target it detected, but there was no guarantee that the new target would actually be the desired one. The process therefore needed to be repeated until the correct target was finally locked.[60]

Once the radar was tracking a target, the radar-measured range information was sent to the A-1's range servo to be converted into a compatible electrical signal (figure 3.7). From there, the range signal was carried to both the sight unit (discussed later) and the amplifier. In the amplifier, the range signal was combined with an electrical signal based on the relative air density, as measured by an aneroid bellows located in the air density unit within the amplifier. The combined signal that emerged from the amplifier, referred to as the sensitivity current, then went then to the sight's prediction computer.[61]

Like the Mark 14, the prediction computer in the A-1 housed two spinning gyroscopes: one to measure changes in elevation, the other to measure changes in horizontal deflection. Draper's team used an unbalanced mass attached to the elevation gyroscope to

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[59] Wells, "Tips and Info for AN/APG-30 Radar"; "Harmonization and Firing Techniques," 42–44; Blake to McCormick, "Request for Communication and Electronic Equipment Data," Inclosure 4; *T.O. 1F-86A-1*, 4–20.

[60] *T.O. 1F-86A-1*, 4–25; Wells, "Tips and Info for AN/APG-30 Radar"; "Harmonization and Firing Techniques," 42–44. Another technique to verify the radar lock was to watch the variably sized reticle (discussed later): "As range decreases, the reticle should grow larger to span target continuously."

[61] Mitchell, "Airborne Fire Control," App 205; Ehrenfried, *General Operating Principles of the A-1*, 20–21; *Type A-1C(M) Gyro Computing Sight*, 26–34; *Operational Suitability Test of the A-1CM*, 10, 12. Adjusting for air density was critical to refining the gunsight's time of flight prediction for the bullet. A unique, gunsight-specific, factory-set calibration was also applied to the sensitivity current.

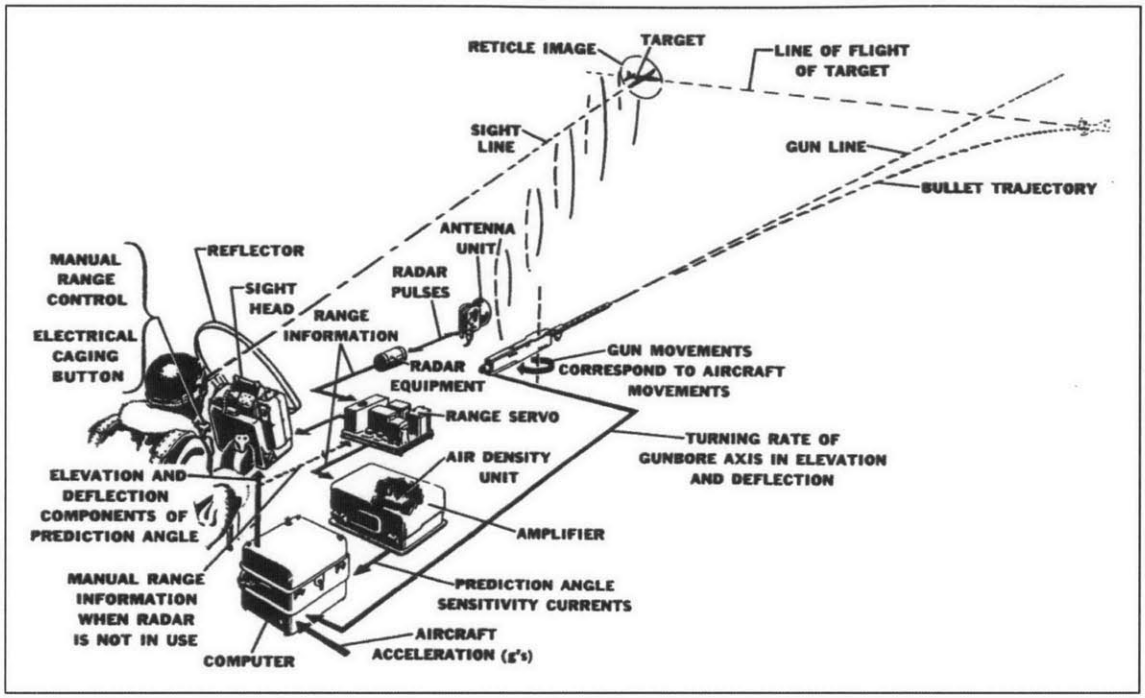

Figure 3.7. A-1 Operation.
(Source: *Harmonization and Firing Techniques*, 26)

measure and account for the effects of gravity drop and velocity jump (figure 3.8). To correct for any rolling tendencies of the attacking aircraft, referred to as cross-roll, the deflection gyroscope was canted ten degrees off horizontal. The pilot could electrically cage the gyroscopes and prevent their precession by depressing an electrical caging button located on the aircraft throttle control. He was instructed to do so while maneuvering into position, thereby eliminating spurious updates to the gunsight computer and limiting potentially distracting reticle movements in the sight.[62]

Once the pilot was tracking the target aircraft and he released the electrical caging button, the gyroscopes were free to detect any changes in angular movement. The changes in motion caused the gyroscopes to apply a torque, proportional to the turning rate of the aircraft, to their respective computer shafts (figure 3.9 shows the elevation computer; the deflection computer was mechanically similar but with the gyroscope oriented ninety-degrees in the vertical). The rotation of the computer shaft was electrically restrained, however, to account for the bullet time of flight according to the sensitivity current produced by the

[62] Ehrenfried, *General Operating Principles of the A-1*, 18; Jenkins, "Some Notes"; "Harmonization and Firing Techniques," 19–20; *Type A-1C(M) Gyro Computing Sight*, 26–34; *T.O. 1F-86A-1*, 4–22.

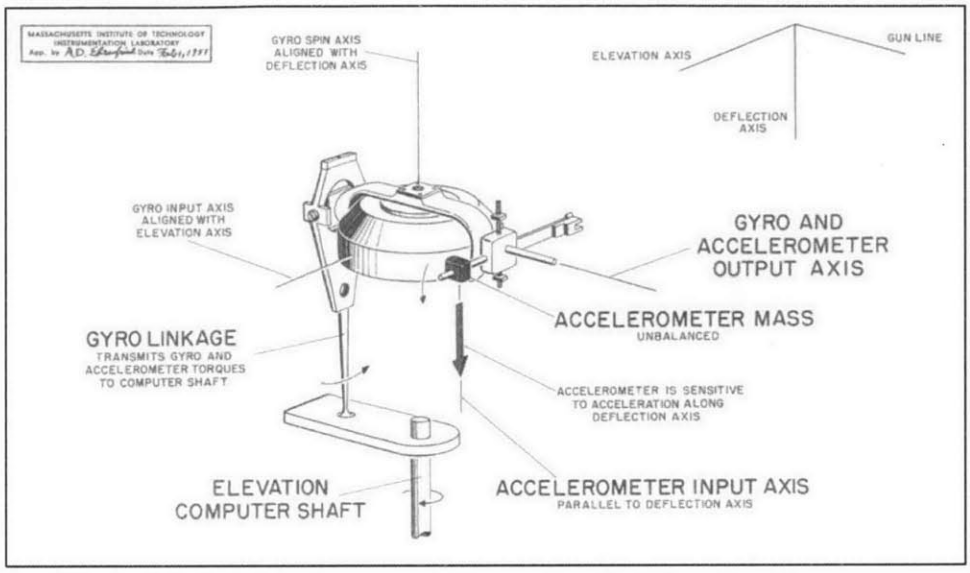

Figure 3.8. A-1 Accelerometer Mounted to the Elevation Gyroscope.
(Source: Ehrenfried, *General Principles of the A-1*, 10)

amplifier. A viscous damper also restrained movement of the computer shaft in order to "smooth and stabilize the prediction computation" over time.[63]

As the computer shaft rotated, a microsyn pickoff measured the torque and generated an appropriate electrical signal that was sent back to the amplifier. There, the elevation and deflection computers' prediction signals were compared with the electric signals produced by the sight unit, which were based on the position of the reticle imaging mirror. If the signal from the sight unit was not coincident with the signal from the prediction computer, the amplifier generated a new signal to drive the mirror in the sight unit into correct alignment. Focused light from a pair of light bulbs located in the sight unit was directed through a collimating lens and projected onto the imaging mirror, which in turn projected the aiming pipper and reticle onto the windscreen in front of the pilot at the appropriate prediction angle.[64]

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[63] Ehrenfried, *General Operating Principles of the A-1*; *Type A-1C(M) Gyro Computing Sight*, 26–34, 44–46; "Harmonization and Firing Techniques," 18–30. Since the dampers directly affected the prediction angle computations, they needed to be precisely controlled, including their operating temperature (specified as between 160° and 180°F). The air temperature in the prediction computer needed to be maintained at 125°F ± 5°F.

[64] *A-1 Series Sight*, 21–23; *Type A-1C(M) Gyro Computing Sight*, 5–10; "Harmonization and Firing Techniques," 21–23. One light bulb provided light for the variable diameter reticle, its size automatically controlled by an adjustable range cone in the sight unit. The other bulb provided the light source for the pipper and, when activated, the fixed diameter reticle.

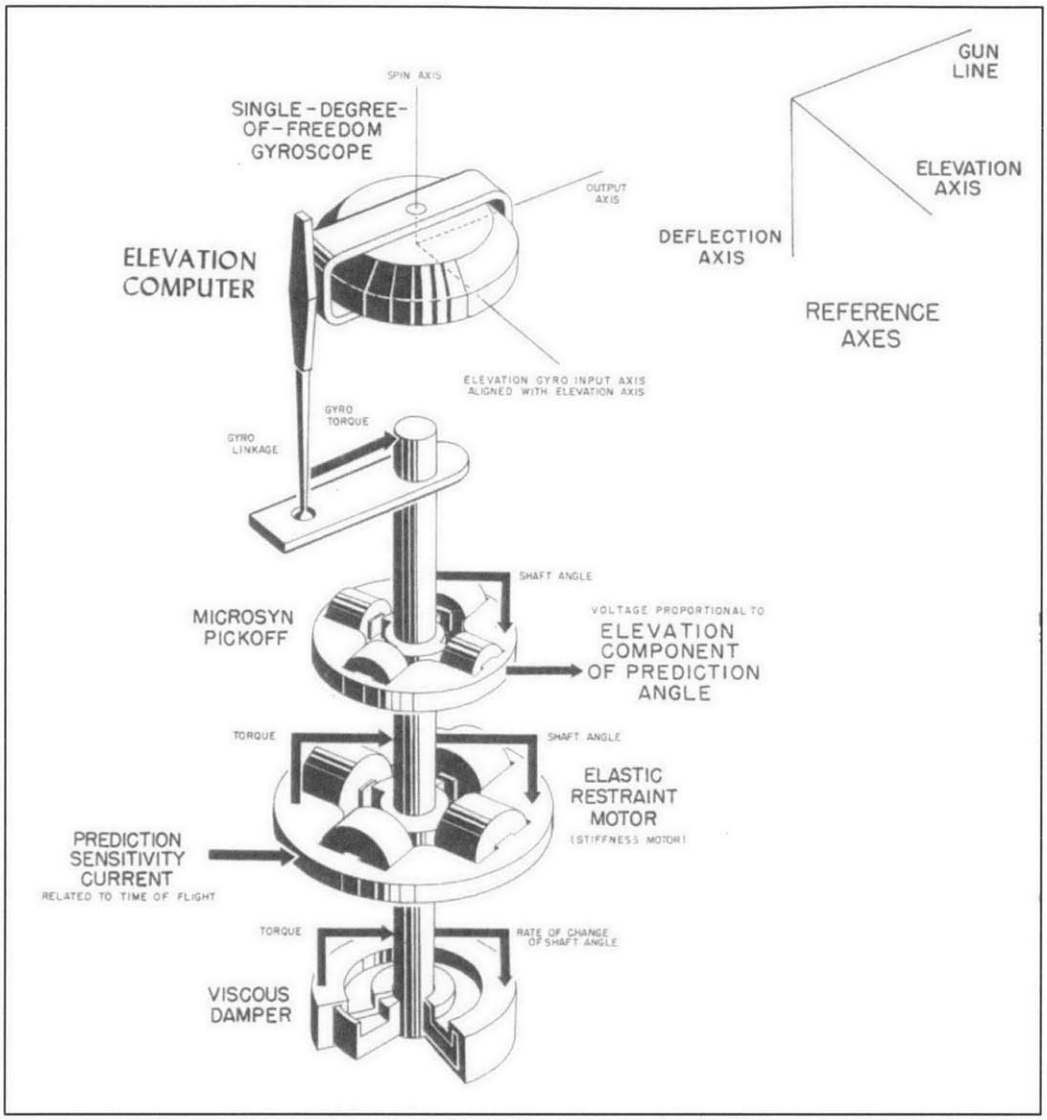

Figure 3.9. A-1 Elevation Computer.
(Source: Ehrenfried, *General Principles of the A-1*, 7)

The sight unit also received the range signal directly from the range servo. This allowed the sight unit to display the target range in the range dial. Additionally, the sight unit used the range input to automatically scale the size of the circular reticle. A distant target had a correspondingly small reticle, and as the range to the target decreased, the size of the reticle increased. The variable range reticle appeared as a solid circle, sized between 20- and 160-mils, with a 2-mil pipper located at the center (left image in figure 3.10).[65]

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[65] *A-1 Series Sight*, 21–23; *Type A-1C(M) Gyro Computing Sight*, 5–10; "Harmonization and Firing Techniques," 21–23.

Knowing that the radar would likely experience tracking issues at low altitudes and in poor weather conditions, and also because the contract demanded it, the A-1's designers incorporated a pilot-controlled stadiametric ranging capability into the gunsight for use as an "emergency measure."[66] Its mechanization mimicked that of the earlier Mk-18. The pilot first engaged manual ranging by twisting the throttle control clockwise, and then adjusted the size of the reticle by continuing to twist the throttle until it matched that of the target (figure 3.11). If the pilot released the applied torque, the throttle was spring loaded to return to the counterclockwise position, restoring the radar's automatic ranging input. Assuming the pilot had earlier set the dimension of the target using the wingspan selector wheel located on the sight unit (similar to the target span selector lever on the Mk-18), the A-1 sight could estimate the range and feed that information to the range dial on the sight unit and to the amplifier for eventual use in the prediction computer.[67]

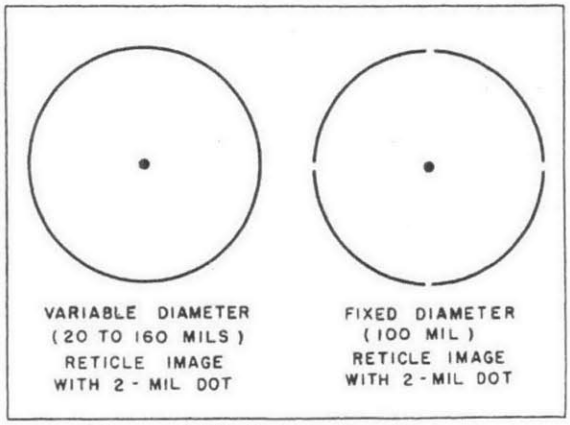

Figure 3.10. A-1 Reticle Images.
(Source: *Type A-1C(M) Gyro Computing Sight*, 44)

Figure 3.11. F-86 Throttle Grip.
(Source: *T.O. F-86A-1*, 1-12)

Finally, engineers also included a way for the pilot to disable the automatic lead-computing function of the A-1 sight. Sliding a lever on

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[66] *A-1 Series Sight*, 3; *A-1 Sight for the Control of Gunfire*, 2; "Fixed Price Contract," Exhibit A; *Accelerated Comparison Test*, Inclosure 1:3; Wildenberg, "A-1C(M) Gunsight," 33–34. When the aircraft was flown at altitudes below about 5,000 feet, the radar became unreliable because it tended to detect the radar reflections from the ground, a problem known as "ground clutter." The radar likewise was rendered unusable when flying in clouds because the radar signal was reflected by the moisture in the air. For more information on ground clutter, see Stimson, *Introduction to Airborne Radar*, chap. 22.

[67] *T.O. 1F-86A-1*, 4–22, 4–25; *Type A-1C(M) Gyro Computing Sight*, 38; "Harmonization and Firing Techniques," 23, 27. The pilot was also reminded to use the electrical caging switch as required during the manual ranging process. The wing span selector wheel was not used in the normal radar-ranging mode.

the sight unit from UNCAGE to CAGE turned off the power to the A-1's amplifier and mechanically caged both gyroscopes in the prediction computer and the reflector mirror in the sight unit. The variable sized reticle was extinguished and a fixed, four-segmented 100-mil diameter reticle was projected onto the windscreen along with the central 2-mil aiming pipper (right image in figure 3.9). No prediction angle was computed and the reticle remained locked in its fixed position along the gun boreline. Returning the switch to the UNCAGE position reactivated the sight.[68]

Although he always retained the option to engage these "emergency measures," the pilot was normally expected to use the full, automatic capability of the new sight and its accompanying radar. Paradoxically, however, the additional automaticity of the new gunsight demanded more complex operating procedures. Whereas operation of the Mk-18 required only four steps (and five accompanying notes) in the flight manual, the A-1C(M) had fourteen steps, plus an additional six if the sight was to be used in manual ranging mode. The first nine helped the pilot prepare the delicate A-1C(M) sight for use. After, among other things, checking the radar power inverter, cycling the cage-uncage lever, and checking the throttle grip in the full counterclockwise position, the pilot was directed to:

> 10. Set wing span adjustment to wing span of target airplane, so that manual ranging can be set up in a minimum amount of time if radar ranging fails.
>
> 11. Adjust sight reticle dimmer control....
>
> 12. Depress electrical caging button to stabilize reticle image, and begin tracking, estimating the lead.
>
> 13. After radar target indicator light comes on ..., release electrical caging button.
>
> 14. Continue to track target smoothly, without slipping or skidding, for approximately one second after releasing caging button; then fire.[69]

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[68] *T.O. 1F-86A-1*, 4–22; *Type A-1C(M) Gyro Computing Sight*, 33; "Harmonization and Firing Techniques," 4–25.

[69] *T.O. 1F-86A-1*, 4–24–25; *T.O. 1F-86E-1*, 4–28–29. There were some minor differences in the order of steps between the F-86A and the F-86E flight manuals. Other A-1 manuals stressed the importance of the initial tracking period and ensuring "that the reticle be held firmly on the target with a minimum of movement. It is particularly important that the 'pipper' is not allowed to drag through the target while firing." Ehrenfried, *General Operating Principles of the A-1*, 20–21; *Operational Suitability Test of the A-1CM*, 10, 12.

The reference to not "slipping or skidding" the aircraft in the final step of the A-1's firing procedures reminded pilots of one of the three critical assumptions that engineers invoked when designing the sight (figure 3.12). First, the sight assumed the target flew a "straight and level [constant velocity] course in the same plane as the attacking fighter." Second, the attacking fighter was assumed to fly a "lead-pursuit course," as commanded by the sight, "with smooth and accurate tracking of the target." Finally, the attacking fighter needed to fly "in a coordinated maneuver with net acceleration and lift vectors in the aircraft plane of symmetry." While not ideal, the three assumptions allowed the engineers to exploit the "special interrelationships among the problem variables," reducing the inputs required to

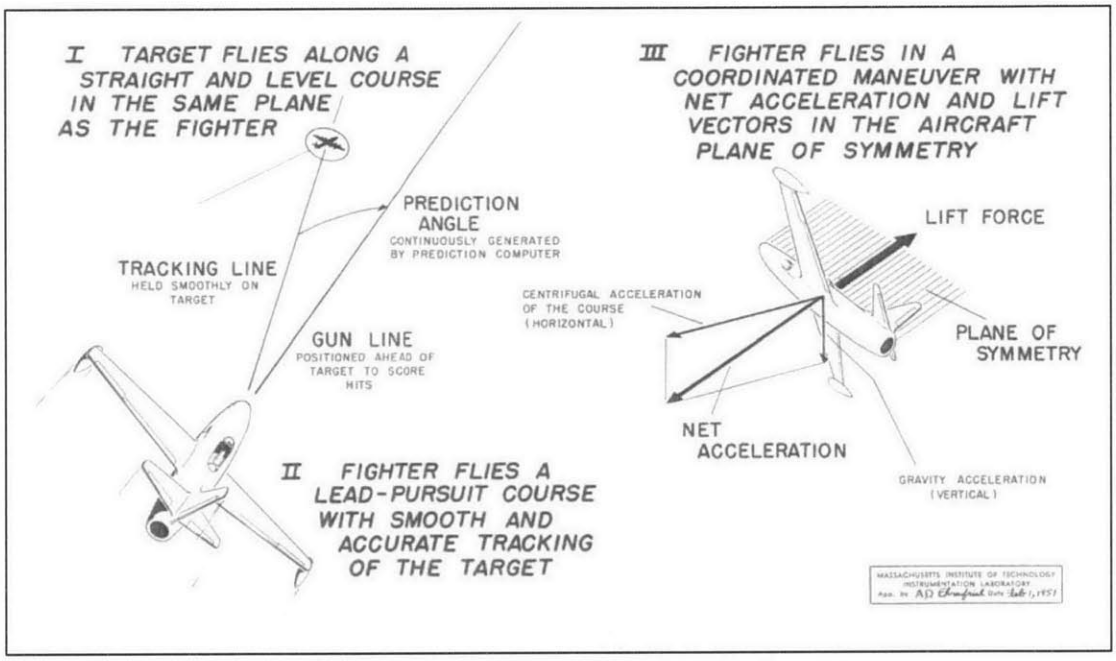

Figure 3.12. A-1 Simplifying Assumptions.
(Source: Ehrenfried, *General Principles of the A-1,* 22)

compute the gun solution to a few, readily measurable quantities. The net result was that the MIT engineers were able to design a "simpler, smaller and more reliable" gunsight that nonetheless still functioned over "an extremely wide range of intercept conditions." However, if any of the assumptions were violated, the "usefulness of the computer," one operating manual warned, would become "somewhat limited" due to the "appreciable error" in the computed solution.[70]

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[70] Ehrenfried, *General Operating Principles of the A-1*, 22–23; *Operational Suitability Test of the A-1CM*, 8; "Harmonization and Firing Techniques," 15, 128–32. For example, if the fighter was flying an *uncoordinated* maneuver (such as a slip or skid) in violation of the third assumption, then the bullet's velocity-jump due to

All told, the A-1 gunsight was seen as a significant improvement in air combat lethality. Air Force test pilots enthusiastically declared the A-1 "superior to any other fixed Gun Fire Control system." By using a radar to "automatically and continuously" feed target range information to the prediction computer, the gunsight eliminated the cumbersome requirement for the pilot to manually span the target with his reticle. Accordingly, several manuals triumphantly declared that the new sight finally allowed "the pilot to direct his full attention to the selected target," a curious but likely unrecognized allusion to Sperry President Tom Morgan's earlier announcement regarding the powers of the Navy's Mark 14. The radar also eliminated a major source of error in the calculated gunnery prediction angle—the pilot's notoriously inaccurate range estimates to the target. Consequently, the Air Force predicted that long-range, high-deflection gun shots would soon become the norm, and commanders in the field were told "to encourage long range firing in their units."[71] Hoping to keep their system isolated from direct pilot intervention, the A-1's designers actively discouraged pilots from doing anything but simply following the commands of their "precision instrument." In the engineer's model, the pilot was on-board simply to aim the guns by aiming his aircraft (figure 3.13).[72]

Davis's efforts had successfully shifted the armament engineers' focus from hitting the target with more reliable guns to more reliably aiming those guns. However, as the pilots in the skies over Korea soon learned, the sight that was touted as being "almost completely automatic" wasn't; it demanded close supervision to ensure it was operating correctly. The A-1 sight demanded more checklist steps and, paradoxically, it required the pilot to visually estimate the target's range in order to verify the sometimes-suspect radar-supplied range. Moreover, there were still several intermediate steps that needed to occur between the time the pilots trudged out to their aircraft and when they squeezed the trigger. The Sabre pilot still needed to get airborne, travel hundreds of miles to MiG Alley, and then visually detect

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centrifugal force would not be in the same plane as the elevation gyro and could not be measured by the attached unbalanced mass, rendering the A-1's computed prediction angle incorrect

[71] *Operational Suitability Test of the A-1CM*, 2, 10; *A-1 Series Sight*, 2; *Type A-1C(M) Gyro Computing Sight*, 3; Mindell, *Between Human and Machine*, 221. See note 29, this chapter.

[72] Getting, "Conference on Fighter Fire Control," I–5; Olsen to Holland, Schwarze, and Rhame, "Evaluation of Results." After observing pilots use the A-1 gunsight during the 1950 Air Force Gunnery Meet, MIT engineers expressed their hope that the experience made clear to the aviators that "as with any precision instrument used in flight, snap decision corrections or judging will not improve results obtainable with the A-1C sight over those possible if correctly employed."

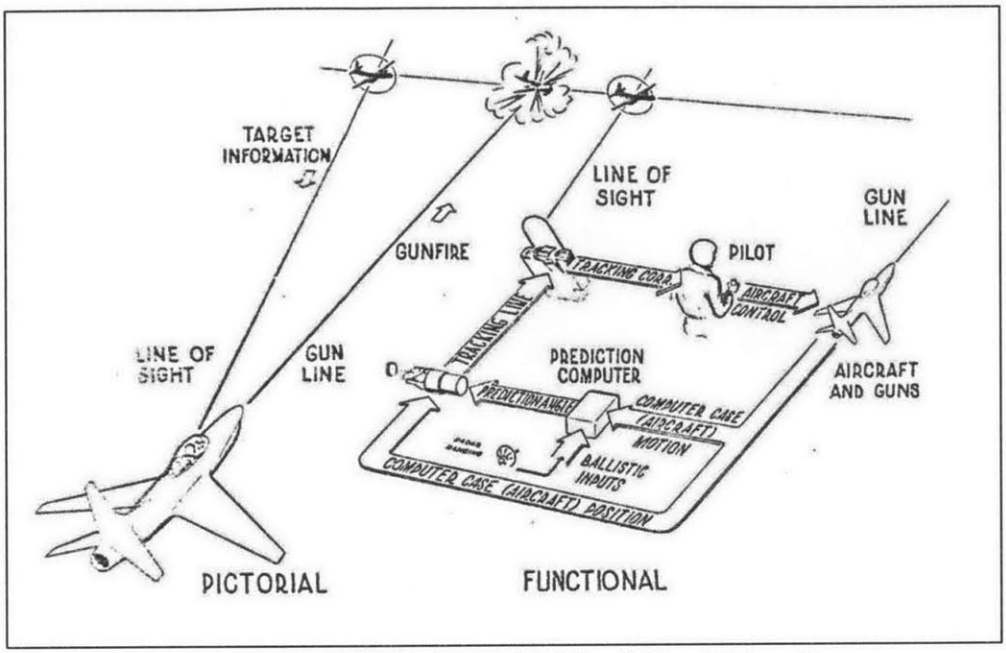

Figure 3.13. A-1 Sight in Air-to-Air Fixed-Gun Fighter System.
(Source: Getting, "Conference on Fighter Fire Control," I-5)

the small, high-flying Communist fighter planes. Then he had to maneuver into a stabilized offensive position behind his target and maintain that position long enough to develop a firing solution before the maneuvering MiG spoiled his tracking. Throughout it all, the Sabre pilot had to maintain constant awareness of his aircraft—lest he run out of fuel—and the sky around him—lest he or his wingman rapidly transform from hunter to hunted. In short, although the A-1C(M) promised unparalleled automatic aiming accuracy, "the electronic wizard" did not guarantee a successful combat outcome in the frenetic skies over MiG Alley.[73]

Within a few months of the A-1's arrival in the combat theater, a cartoon appeared in the *Fighter Gunnery Newsletter* (figure 3.14). It captured the pilots' emerging opinion of their new, highly touted sight: what began as a brilliant idea emerging from MIT had been transformed into a monstrosity that was figuratively crushing the life out of the fighter pilot; it was neither useful nor practical in the F-86 in the skies over Korea. To appreciate this sudden shift in the pilots' attitude, we next need to look at the circumstances of Korean air combat.

[73] "New Radar Sight Guides Jets' Guns."

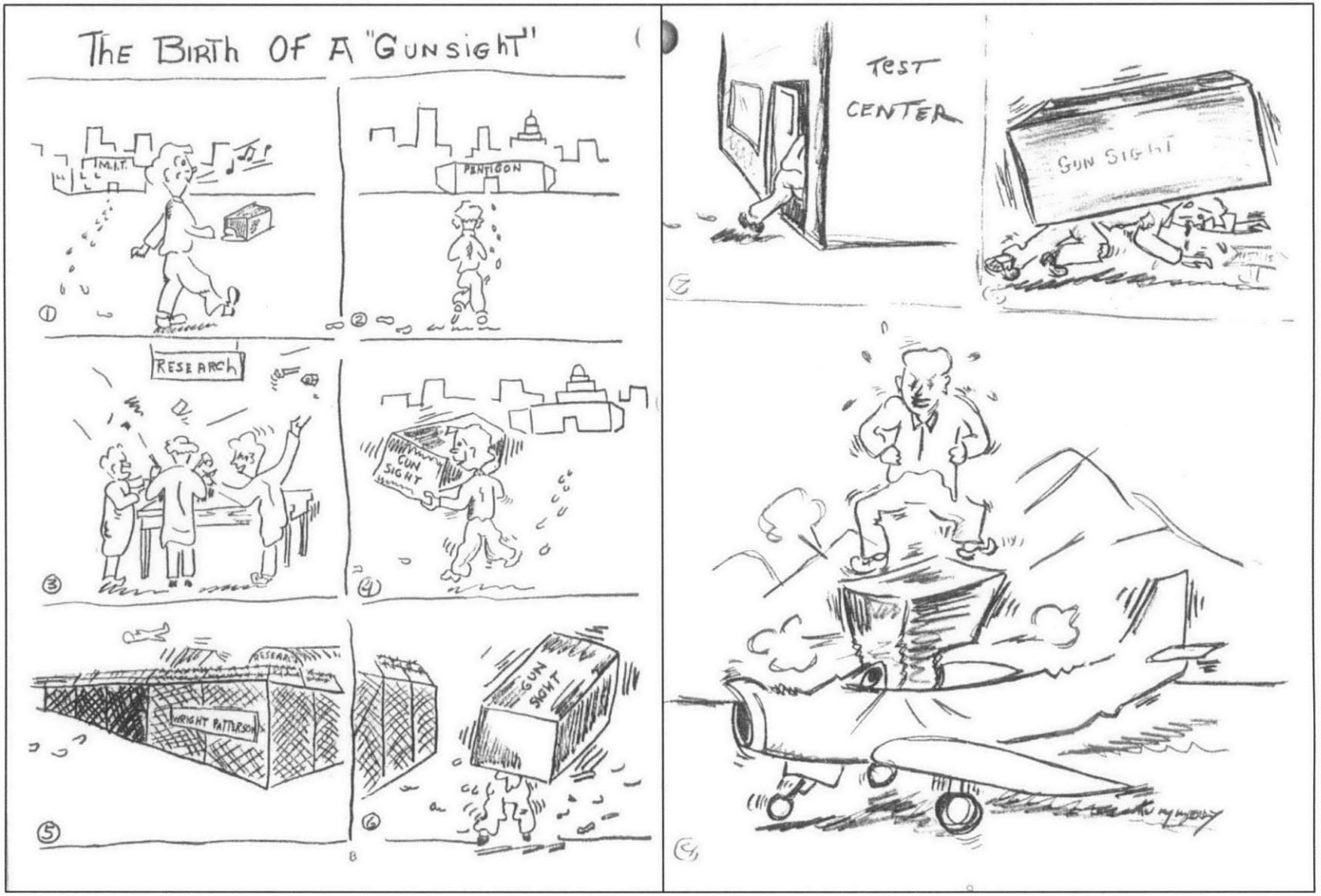

Figure 3.14. Birth of a "Gunsight."
(Source: *Fighter Weapons Newsletter*, 1 (1951):3)

Thrust into War

Few would have predicted that the new A-1C would first see action in the skies over Korea. Yet, that's where it found itself in mid-1951 as F-86 pilots battled against a Communist foe flying Soviet-built MiG-15 fighters. Almost a year earlier, on June 25, 1950, North Korean troops raced south across the 38th Parallel and into South Korea. At the time, the North Korean Air Force (NKAF) consisted of a motley collection of World War II "hand-me-downs" bequeathed to them by the Soviets. Despite being neither numerically nor technologically impressive, the North quickly commandeered control of the sky that first day and scored several blazing victories.[74]

The North Koreans' domination in the air was, however, extremely short-lived. Two days after the initial invasion, American F-82 Twin Mustangs and F-80C Shooting Stars downed a total of eight NKAF fighters.[75] As the Communist troops advanced farther south toward Pusan during the summer, the US Air Force launched a massive effort to eradicate the NKAF. US crews in B-29 Superfortresses assigned to the Far East Air Forces (FEAF) pummeled the North's airfields, while their Fifth Air Force friends in B-26 light bombers and F-51 fighters strafed any remaining planes left on the ground. Pilots flying above in F-80C jet fighters scored easy victories over any NKAF aircraft that managed to get airborne.[76] By early October 1950, following General Douglas MacArthur's daring amphibious landing at Inchon, North Korea's army was in full retreat and its air force was in shambles.[77] The

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[74] Hone, "Korea," 459; Y'Blood, *MiG Alley*, 1; Futrell, *United States Air Force in Korea*, 7; Stratemeyer, *Three Wars of Lt. Gen. George E. Stratemeyer*, 37. At the start of hostilities, the NKAF possessed sixty-two Il-10 ground attack aircraft, seventy Yak-3 and Yak-7B fighters, and twenty-two Yak-16 transports. In contrast, the entire South Korean Air Force consisted of sixteen aircraft. The NKAF attacks against the airfields at Kimpo and Seoul damaged a control tower, destroyed a disabled American C-54, and crippled seven of ten South Korean aircraft parked on the ground.

[75] Futrell, *United States Air Force in Korea*, 9–13. Five Yak fighters intent on disrupting airlift operations out of Kimpo were confronted by five F-82 fighters; the Americans destroyed three of the Red fighters before the other two fled. Later that day, eight IL-10 fighters tried to return to Kimpo, but they were met by four F-80C jet fighters; the NKAF's propeller-driven fighters proved no match for the American jets, which quickly flamed four more aircraft with no losses.

[76] Ibid., 2–4, 67–70, 98–103. FEAF, initially led by General Stratemeyer, represented the USAF component of Far East Command, which was led by General Douglas MacArthur. Three numbered air forces were assigned to FEAF: Fifth Air Force, headquartered at Itazuke AB, Japan; Twentieth Air Force, based out of Okinawa, Japan; and Thirteenth Air Force, operating from Clark AB, Philippines. Because of its proximity to the action, Fifth Air Force would provide the preponderance of tactical aircraft for use in the Korean War. Rather than being assigned to a numbered air force, the B-29s on-loan from SAC remained under direct control of FEAF.

[77] Hone, "Korea," 462; Warnock, *USAF in Korea*, 8; Y'Blood, *MiG Alley*, 6; Werrell, *Sabres Over MIG Alley*, 71; Stratemeyer, *Three Wars of Lt. Gen. George E. Stratemeyer*, 232; Futrell, *United States Air Force in Korea*, 102.

aerial campaign was so lopsided that "military pundits at every echelon" back in the US began debating "whether conventional aircraft, such as the Air Force Mustang and the Marine Corsair, might not be 'better' aircraft than the Air Force F-80C jets."[78]

All of that changed on November 1 when Communist China intervened on a massive scale. The US and South Korean army positions near the Yalu River were decimated, and the accompanying United Nations (UN) troops commenced a hasty retreat back south.[79] China's entry into the Korean War was also announced in the air that afternoon. Just before two o'clock, a force of six sleek, swept-wing fighters took off from their base in Manchuria and darted south of the Yalu River near Sinuiji, hoping to pounce on a group of unsuspecting British and American aircraft. Miraculously, the Allied pilots in the British Mosquito and American F-51 Mustangs survived the lightning-quick onslaught. The twin-engine Mosquito sped back to its temporary base at Pyongyang to file details of the engagement and spread the astonishing news—"very, very fast" Soviet-built, Chinese MiG-15s were now patrolling the skies over Korea (figure 3.15). The arrival of the new jet-powered MiG instantly "rendered obsolete every American plane" in the theater.[80]

Figure 3.15. Soviet MiG-15*bis*.
The *–bis* was a later version of the MiG-15. Note the mid-mounted wing and the horizontal stabilizer mounted high on the vertical tail—common features on all MiG-15s. Lt. Ro Kum Suk, a North Korean pilot, defected to the South on September 21, 1953, in this MiG-15, which was quickly moved into a hangar at Kimpo. See Futrell, *United States Air Force in Korea*, 652-53. (Source: NMUSAF)

Stratemeyer observed in his diary, "As it happened, the air battle was short and sweet. Air Supremacy over Korea was quickly established." But he cautioned himself in his entry dated October 14, "The principal lesson learned [is] not to draw wrong conclusions from Korean War because of absence of aggressive hostile air." Still, the battle had not been bloodless. For example, on July 12, 1950, the NKAF downed an American B-26, B-29, and L-4 (a military-version of the Piper Cub).

[78] Futrell, *United States Air Force in Korea*, 244; Crane, *American Airpower Strategy in Korea*, 24–26; Stratemeyer, *Three Wars of Lt. Gen. George E. Stratemeyer*, 101.

[79] Appleman, *South to the Naktong*.

[80] Werrell, *Sabres Over MIG Alley*, 61–65; Y'Blood, *MiG Alley*, 10; Futrell, *United States Air Force in Korea*, 218, 244–45; Thompson and Nalty, *Within Limits*, 21–22; Stratemeyer, *Three Wars of Lt. Gen. George E. Stratemeyer*, 252. The MiG-15 was known to American intelligence officers since its unveiling at the July 1948 Moscow airshow. There may have been early signals indicating that China had taken possession of Stalin's vaunted fighter, but they went largely unnoticed. On the Soviet-Chinese-Korean relationship during the Korean War and its influence over the Communist air strategy, see Zhang, *Red Wings over the Yalu*.

Operating from their bases just inside Manchuria, the MiGs immediately began to challenge the American and UN forces' dominance of the air. The high-speed jet fighters easily pounced on American B-29 bombers sent north to fell the bridges spanning the Yalu. Even when the B-29s were alerted to the MiGs' attacks, the automated self-defense gun system on the Superfortresses, a technological marvel when it was developed in the latter stages of World War II, could not reliably shoot down the enemy because the MiGs simply outran the mechanical servos that controlled the bombers' machine gun turrets.[81] Nor were the Americans' F-80s much-better equipped to deal with the MiG threat; although both were jet-powered, the MiGs were more than 100 miles an hour faster than the F-80C, leaving the once-impressive Shooting Star looking "as if it were anchored in the sky."[82]

Seven days after the MiGs were first sighted, the CSAF, General Hoyt Vandenberg, declared his intention to ship his service's premier fighter aircraft to the war. A week later, F-86As from the 4th Fighter-Interceptor Wing (FIW) in Wilmington, Delaware, and F-84Es from the 27th FIW at Bergstrom AFB, Texas, began arriving in California to be loaded onto four tankers and three Navy escort carriers and then shipped off to war. The first batch of Sabres completed the trans-Pacific journey the first week of December; the second batch arrived the following week on the thirteenth (figure 3.16).[83]

After some hasty repairs made necessary by the long ocean voyage, the Sabres were flown to Kimpo airfield, located just northwest of Seoul.[84] It was the closest airfield to the

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[81] Bruning, *Crimson Sky*, 161; Futrell, *United States Air Force in Korea*, 220–30; Futrell, *USAF Operations in the Korean Conflict, 1 Nov 1950 - 30 Jun 1952*, 8–9.

[82] Futrell, *United States Air Force in Korea*, 223, 244; Boatner, "Letter Report on Relative Aerial Combat Capability." Despite its disadvantages, the F-80C did enjoy occasional success against the MiG-15. The November 8, 1950 engagement between a MiG-15 and an F-80 piloted by Lieutenant Russell J. Brown has historically been celebrated by the Air Force as the "first jet-to-jet aerial victory in history." Warnock, *USAF in Korea*, 23; Stratemeyer, *Three Wars of Lt. Gen. George E. Stratemeyer*, 269. However, recent scholarship suggests that there was no enemy downing that day and the honor should be awarded to US Navy Aviator William Amen for destroying a MiG on November 9; see Zhang, *Red Wings over the Yalu*, 88.

[83] Stratemeyer, *Three Wars of Lt. Gen. George E. Stratemeyer*, 175, 267–68, 272, 277; Futrell, *United States Air Force in Korea*, 248; Sherwood, *4th TFW Chronology*, 30; *History of the 4th Fighter-Interceptor Group, Oct -Dec 1950*, 5; Crane, *American Airpower Strategy in Korea*, 26. Senior Air Force officials in Washington repeatedly refused FEAF's and Stratemeyer's earlier requests for new aircrews and new aircraft, citing limited inventories of F-86s and pressing "air defense" requirements in the US. The Fourth had been flying the F-86A Sabre since the end of March 1949.

[84] Sherwood, *4th TFW Chronology*, 30; Werrell, *Sabres Over MIG Alley*, 76–77; Futrell, *USAF Operations in the Korean Conflict, 1 Nov 1950 - 30 Jun 1952*, 17, 122. Most of the newly arrived aircraft required varying levels of repair when they arrived: their brakes, wheels, flight control surfaces, and electrical terminals had not responded well to the hasty and improper shrink-wrapping applied to the aircraft before they were dumped

MiGs' bases in Manchuria that could support F-86 operations, but the Sabres still had a long, 200-mile journey north from Kimpo before they encountered the MiGs. Moreover, because Kimpo was overcrowded with aircraft when the Sabres arrived, only a portion of the 4th's F-86s were placed on the peninsula. With just seven serviceable aircraft and fourteen pilots, Detachment A of the 336th Fighter-Interceptor Squadron, 4th FIG, launched the first F-86 missions of the Korean War on December 15, 1950. Their primary assignment was "to seek out and destroy hostile aircraft on the South side of the Yalu River."[85]

Figure 3.16. North American F-86E Sabre.
The E-model of the F-86 would start trickling into Korea in mid-1951. In contrast to the MiG-15, note the Sabre's low-mounted wing and horizontal stabilizer. (Source: NMUSAF)

Two days later, the F-86s had their first opportunity. On December 17, 1950, Lieutenant Colonel Bruce Hinton led four of his squadron-mates on the second Sabre mission of the day. Spotting a group of MiG-15s below, Hinton quickly positioned his flight to attack. One history of the engagement described the MiG pilots' initial response as "perfunctory and leisurely," the Red pilots having grown accustomed to battling "those type aircraft whose speed and climbing ability was somewhat inferior to their own." A fifteen minute dogfight ensued before Hinton, using the Sabre's Mk-18 gunsight, successfully fired "fifteen hundred rounds of fifty caliber ammunition into" one of the MiGs. "Multiple hits were observed; debris falling away and finally, the entire rear section of the aircraft was enveloped in flame as it began spinning." The 4th triumphantly declared that its F-86s "had engaged and destroyed an aircraft reputed to be the highest performing aircraft known in the enemy's airforce."[86]

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aboard the tankers, and the harsh ocean salt spray had similar corrosive effects on those aircraft that were strapped to the open decks of the escort carriers.

[85] Hinton and Wingo, "Analysis of Operations at Kimpo," 1; *4th FIG Tactical Doctrine*, July 22, 1951, 1. The December 15 mission "was uneventful, serving only to familiarize the pilots with routes to be traversed on missions of future dates." The following day, bad weather grounded the Sabres. The F-86 unit at Kimpo reached full strength on December 24.

[86] Hinton and Wingo, "Analysis of Operations at Kimpo," 8–10; "Enemy Air Activity, 17 Dec 1950"; Limpantsis, "FEAF Intel Form 1, 17 Dec 1950."

Vying for Air Superiority

A thirty-month long battle ensued as MiGs and Sabres battled for control of the sky over the Korean peninsula. For most of the war, American military leaders were intent on using aerial bombing to stem the tide of Communist supplies crossing the Yalu from Manchuria into North Korea. To do that, they needed the sky to be made relatively clear of enemy MiGs. While the Americans would have preferred to destroy the enemy jet aircraft in bulk on the ground by bombing their airfields in Manchuria, political restrictions prohibited that course of action.[87] Instead, the Americans needed their Sabres to destroy the MiGs in the air. The Communists, understandably so, did not want to cede air superiority, and their MiG pilots fought vigorously to upset the American plans. The majority of these aerial battles took place over the northwest corner of North Korea between the Chongchon and Yalu Rivers, just across from the main MiG base at Antung in off-limits Manchuria. The area became known as MiG Alley (figure 3.17).

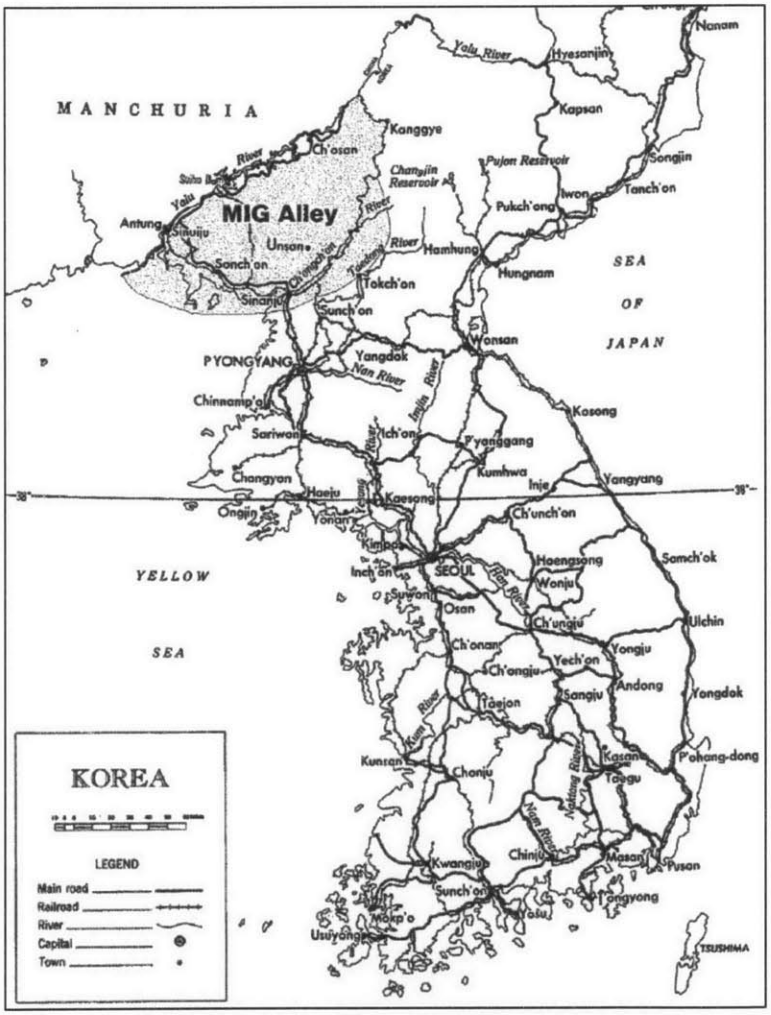

Figure 3.17. Korea and MiG Alley.
(Source: Zhang, *Red Wings over the Yalu*, 93)

[87] *FEAF Report on the Korean War*, II:2; Futrell, *USAF Operations in the Korean Conflict, 1 Nov 1950 - 30 Jun 1952*, 18–19, 42–43; Stratemeyer, *Three Wars of Lt. Gen. George E. Stratemeyer*, 262–67. The Joint Chiefs of Staff doggedly refused to grant MacArthur approval to bomb Chinese targets north of the Yalu. While many aviators complained of the Communists' aerial sanctuary in Manchuria, UN forces also enjoyed a *de facto* sanctuary out over the water; UN pilots repeatedly observed their MiG foes abruptly disengage when the fight drifted past the Korean coastline. See, for example, Mahurin, *Honest John*, 92–93.

The importance of gaining air superiority as a prelude to an aerial bombing campaign, or any campaign on land or sea for that matter, was one of the dramatic lessons of the Second World War. Reflecting on the earlier wartime experience, US Army spokesperson Robert Patterson testified in 1947, "Without command of the air, the launching of a military operation on land or sea was virtually unthinkable."[88] Across the Atlantic, the Royal Air Force's Lord Tedder was similarly espousing "the outstanding lesson of the late war," that "in order even to begin to wage war successfully, it is necessary to arrive at the situation in which the enemy air opposition is unable to interfere effectively with our own operation—that is what we mean by air superiority."[89]

The significance of the Sabres to the aerial campaign was demonstrated in dramatic, albeit negative, fashion shortly after their arrival in Korea. With Chinese troops advancing on Seoul, the Americans were forced to abandon their base at Kimpo on January 2, 1951, and relocate their fighters to Japan. Lacking the air cover normally provided by the Sabres, FEAF's bombers had to discontinue their attacks to the far regions of North Korea. The Chinese and North Koreans used the lull in the bombing to train additional MiG-15 pilots and to make extensive repairs to their airfields south of the Yalu River. This included several "secret" runways hidden just north of the 38th Parallel that the Communists hoped to use to extend their umbrella of MiG-provided air superiority farther south. Only after the UN troops recaptured the airfields at Suwon and Kimpo, and the Sabres returned to their bases near the 38th Parallel, could the FEAF bombers be put back into action. That didn't occur until early March.[90]

Even then, despite their best efforts, the Americans couldn't make the aerial bombing campaign in Korea match that of the Second World War. The inability to strike lucrative targets in Manchuria, to include the MiGs' airfields, was only one aberration. Additionally, unlike in Germany, North Korea possessed precious few large, industrial

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[88] Quoted in Futrell, *Ideas, Concepts, Doctrine, 1907-1960*, 171–72. See also Momyer, *Airpower in Three Wars*, 125–29.

[89] Tedder, *Air Power in War*, 32–33, 44. Tedder presented his views in a series of lectures on "Air Power in War" at Cambridge University in 1947.

[90] Futrell, *United States Air Force in Korea*, 278–80, 293–96. Suwon was recaptured at the end of January 1951, but remained "a waterlogged, bomb-pitted, concrete runway in the middle of a sea of mud" through early March. Unable to support full operations, it was used as an intermediate staging base by the Sabres beginning on March 6, 1951. Anticipating the return of the Sabres, FEAF sent its B-29 bombers back north five days prior, but the results were catastrophic—ten Superfortresses damaged, three severely.

targets amenable to massive strategic bombing. Rarely could the Air Force allocate hundreds of aircraft to a single nondescript Korean target. Plus, many of the bomber escort tactics perfected by the fighter pilots during the prior world war were rendered obsolete by the speedy new MiGs.[91] Consequently, the Americans were never able to exploit the synergy between bomber and fighter that years earlier had compelled the *Luftwaffe* to choose between giving battle in the air or being destroyed on the ground.[92] Throughout the war, the Chinese could chose when and where to concentrate their MiG aircraft in order to achieve overwhelming superiority against the often piecemeal American forces.

Facing a numerically superior foe that largely retained the tactical initiative, the F-86 pilots were left trying to defend the bombers and win air superiority one downed MiG at a time.[93] It was a daunting assignment, marked by frequent, heavy losses of the prized B-29 bombers. In October 1951, the Air Force chose to suspend its B-29 daylight precision bombing efforts rather than watch its bomber inventory continue to dwindle. The B-29s were shifted to night-duty, leaving the more maneuverable but less destructive F-84 fighter-bombers for the daylight bombing sorties. Although an acknowledgement of temporary defeat, the shift in strategy was welcomed by the Sabre pilots who loathed the difficult bomber-escort missions. Now the Sabre pilots were free to perform "fighter sweep," the "most desired and enjoyed" mission because, they said, it presented "the best possibilities for an individual to demonstrate his ability and his aggressiveness as a fighter pilot."[94]

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[91] "Special Subject: Two Years of MiG Activity," IV–11; Futrell, *United States Air Force in Korea*, 413–15, 421; Futrell, *USAF Operations in the Korean Conflict, 1 Nov 1950 - 30 Jun 1952*, 88–89; Werrell, *Sabres Over MIG Alley*, 84–86, 125–26; Crane, *American Airpower Strategy in Korea*, 83–89; Preston to Commanding Officer, 4th Fighter Interceptor Wing, "Analysis of F-86 Fighter Encounter," 5. Sabre pilots repeatedly expressed concern over their inability to protect the lumbering B-29s that were attacking targets near the Yalu. For example, one September 1951 memorandum by Preston emphasized "that it would be virtually impossible to completely stop a determined attack against a formation of B-29s by aircraft as fast as the MiG-15."

[92] Futrell, *USAF Operations in the Korean Conflict, 1 Nov 1950 - 30 Jun 1952*, 114–15; McFarland and Newton, *To Command the Sky*.

[93] Peterson, "F-86A Operation as a Fighter-Interceptor," 2; *FEAF Report on the Korean War*, II:2; Mahurin, *Honest John*, 37; Gabreski, "(End of Tour) Report," 4; McMillin et al., "FEAF Intel Form 1, 18 Jun 1951." FEAF officials complained, "The entire air war in Korea was characterized and influenced by several conditions which rendered this conflict unique and unprecedented in the annals of military history." Mahurin described the frustration as being "exactly as though one professional boxer were asked to fight another with one hand behind his back." The exasperation is palpable in the post-mission summary from June 18, 1951.

[94] *4th FIG Tactical Doctrine*, December 28, 1952, 7–9, 23; *Resume of Our Tactics*, 7, 12–13; *FEAF Report on the Korean War*, II:8–9; Futrell, *USAF Operations in the Korean Conflict, 1 Nov 1950 - 30 Jun 1952*, 112; Hinton, "MiG-15 Versus F-86A," 20–21.

Still, the air war for the Sabres remained challenging. The MiG pilots were experts at exploiting their nearby sanctuary in Manchuria to maximize their tactical advantage.[95] As one early assessment of Korean air combat noted, "the enemy could choose if he wished to meet the F-86 or not, and, if so, could choose the time, relative number of aircraft and usually the method to begin the encounter."[96] For the first few months of the Sabre-MiG battles, the MiG pilots tended to use "hit-and-run passes" during their attacks. The MiGs would launch from their sanctuary bases in Manchuria in flights of four, climb high above the Sabres while remaining just north of the Yalu River, and then sweep south, splitting up into elements of two, for a one-pass attack against the American aircraft before speeding back north to safety. Often, the MiGs tried to time their passes so that the first element could act as "decoys," overshooting the American fighters and luring them into a position so that the second element of MiGs could score an easy kill.[97]

Beginning in mid-1951 and lasting through the following April, American pilots noticed a shift in the complexity of the MiGs' tactics. For example, newly observed "Yo-Yo" attacks involved up to twenty MiGs. From an "up-sun" position and "usually in elements of two, the enemy would peel-off and attack from high astern, come in firing, and zoom-climb back" to altitude to rejoin the pack of orbiting MiGs. The MiGs' "pincer and envelopment tactic" was even more complex, involving two massive formations of sixty to eighty MiGs each, which were carefully choreographed to fly south, turn to meet up near Pyongyang, and then proceed north in search of UN fighter-bomber aircraft and low-on-fuel F-86s that were flowing south. During this period, it was not infrequent for the F-86s to be outnumbered two or three to one in a dogfight; occasionally the numerical disadvantage even reached

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[95] *FEAF Report on the Korean War*, II:3–4; Hinton, "MiG-15 Versus F-86A," 13; Hise, "Analysis of the Tactics of Aerial Warfare," 1, 13, 15; Beckwith to Deputy for Intelligence, 5th Air Force, "Re-Evaluation of MiG-15 Tactics." In its final report on the Korean War, FEAF identified "five distinct phases" of air combat between the MiG-15 and the F-86, "each apparently resulting from a change in enemy tactical concept." *cf.* "Special Subject: Two Years of MiG Activity"; "Growth of MiG Alley." Also, within each phase, a "cyclic rise and fall in air activity" and pilot proficiency was observed, eventually leading many intelligence analysts to conclude, correctly, that whole Chinese and/or Russian units were being rotated in and out of Korean combat. Hise, "Markings on MiG-15 Type Aircraft"; Hise, "F-86E versus MiG-15 in Korea," 16; Zhang, *Red Wings over the Yalu*.

[96] Peterson, "F-86A Operation as a Fighter-Interceptor," 2.

[97] Hise, "Analysis of the Tactics of Aerial Warfare," 1, 13, 15; Beckwith to Deputy for Intelligence, 5th Air Force, "Re-Evaluation of MiG-15 Tactics."

fifteen to one. Recalling his October 5, 1951, mission, Evans described seeing a "blob" of eighty MiGs—"an awe-inspiring sight—in fact, I was so awed I figured we'd all had it."[98]

However, despite the abundance of MiGs in the sky and their occasional bouts of aggressive, offensive action, most days the MiGs chose not to battle the Sabres. FEAF intelligence officers eventually reasoned that the Communists must have been conducting "mass training," allowing their "new pilots [to] observe the application of classroom theory" as "their more experienced brothers demonstrated combat tactics through occasional engagements."[99] It was an incredibly unsatisfying period for the Americans as they watched the MiGs soar high above them. On one November 1951 mission, Sabre pilots reported seeing "30 MIGs … high in contrails headed southward but no contact was made"; the F-86s returned home from the mission empty-handed. Some Sabre pilots even tried goading the MiGs to fight, but more often than not, the MiGs did not take the bait.[100] Paddy Harbison, then a British-exchange pilot flying F-86s with the 4th at Kimpo, recalled the difficulty he experienced "enticing the MiGs to engage. It was very frustrating to fly to the Yalu, … see these enormous formations tracking back and forward in contrails above us, and not being able to engage them."[101]

The Americans couldn't engage the MiGs because their Sabres couldn't match the altitude and climb performance of the MiGs. Nor could they match the MiGs' numbers. Nothing could be done quickly to remedy the former issue, but the Air Force finally chose to address the latter issue in October 1951.

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[98] "Growth of MiG Alley," 53; Futrell, *United States Air Force in Korea*, 404; "Special Subject: Two Years of MiG Activity," IV–10–11; Futrell, *USAF Operations in the Korean Conflict, 1 Jul 1952 - 27 Jul 1953*, 53; Y'Blood, *MiG Alley*, 26; Thyng, "Operation of the 4th Fighter Wing in Korea," 8; *Resume of Our Tactics*, ii; Evans, *Sabre Jets Over Korea*, 89, 119. In December 1951, American pilots reported seeing eight-times as many MiGs as they had six months earlier, including 366 spotted on a single day. Evans expressed his displeasure with the situation: "I get mad as hell when I think of the odds we have to contend with, plus the superior climb, altitude, and acceleration ability of the MiGs."

[99] *FEAF Report on the Korean War*, II:4–5; "Special Subject: Two Years of MiG Activity," IV–11–12. FEAF intelligence officials also wondered, "perhaps the Reds believed something could be gained … by displaying an overwhelming force in order to impress UN pilots."

[100] Howard and Hise, "FEAF Intel Form 1, 18 Nov 1951"; Hinton, "MiG-15 Versus F-86A," 5–6.

[101] Quoted in Hallion, "Air Dominance," 40. Harbison continued, "When they decided to engage, they came down to attack us in numbers. Once they did that, we could mix it with them, but, if they wanted to, they could stay out of trouble."

Upping the Ante

On October 22, 1951, General Vandenberg had finally had enough. For more than a year, the Air Force had tried to fight the Korean War with a shoestring force. Following a particularly disastrous week in which several B-29s were lost to MiGs, Vandenberg ordered Air Defense Command to surrender seventy-five of its eighty-one newest F-86Es for immediate transport to Korea. Shortly thereafter, he also initiated contracts to purchase more F-86s then starting to roll off production lines in Canada. The majority of the new F-86Es were originally destined for the 51st FIW at Suwon, which agreed to exchange its F-80Cs for the new Sabres, but a portion eventually found their way to the 4th at Kimpo. Even with 165 Sabres—a mixture of A- and E-models—located on the peninsula by December 1951, the Americans were still outnumbered by a combat-ready MiG force five to ten times larger located just across the border in Manchuria.[102]

Compounding the numerical inequality, the Americans Sabre pilots who walked through the Torii gate at Kimpo on their way to their jets had a nearly 200-mile journey back and forth to MiG Alley (figure 3.18). The Sabres began carrying jettisonable 120-gallon external tanks to augment their fuel capacity, but even then their time spent patrolling MiG Alley was limited to between twenty and twenty-five minutes due to the long transit distances. Worried that they would run out of gas during a heated battle, some pilots took to carrying alarm clocks to remind them when it was time to head home. Several did run out of gas, including Blesse on what would be his final mission in Korea. On other occasions, the external tanks would not jettison, which meant that the encumbered Sabre needed to abandon its flight and turn around for home, further dwindling the number of American fighters in the air on patrol.[103]

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[102] Futrell, *United States Air Force in Korea*, 391, 402–4, 413–15, 421; Futrell, *USAF Operations in the Korean Conflict, 1 Nov 1950 - 30 Jun 1952*, 82, 88–89; *United States Air Force Statistical Digest: Fiscal Year 1953*, pt. I; "Special Subject: Two Years of MiG Activity," IV–12; Werrell, *Sabres Over MIG Alley*, 84–86, 125–26; Y'Blood, *MiG Alley*, 24, 28–29; Crane, *American Airpower Strategy in Korea*, 83–89; Mahurin, *Honest John*, 38. Vandenberg's decision represented a sudden reversal from an earlier memo dated September 20, 1951, that announced no more F-86s would be sent to Korea.

[103] Futrell, *United States Air Force in Korea*, 250, 296, 419; *FEAF Report on the Korean War*, II:15; Thyng, "Operation of the 4th Fighter Wing in Korea," 4; Evans, *Sabre Jets Over Korea*, 91, 98, 209; Sherwood, *Officers in Flight Suits*, 83; Blesse, *Check Six*, 65–66, 72–76. Often, a pilot would suddenly find himself engaged with MiGs and dangerously low on fuel, as Evans did on October 5, eventually landing with less than 20 gallons in his tank. Evans later joked that because of his fellow pilots' tendency to return home low on fuel (or out of fuel), they should rename "the outfit to the 4th Glider Group." After the war, FEAF determined that "jettisonable fuel tanks represented the largest single operating cost of an F-86 fighter interceptor wing." Thyng noted that

Additionally, the MiGs maintained a slight edge in key performance parameters, notably climb rate, maximum altitude ceiling, and horizontal acceleration, all stemming from the Soviet's lighter-weight design. The MiG-15 could also turn tighter and it possessed more powerful but slower firing guns, consisting of one 37- and two 23-mm cannons. An updated version of the MiG-15, the *–bis*, sporting a more powerful VK-1 engine, began appearing in the skies over Korea in mid-1951. Many American pilots were crestfallen when they started seeing the new MiGs flying in formation at altitudes approaching 55,000 feet, almost a mile above the highest Sabres.[104]

Figure 3.18. Torii Gate Leading to the Flightline at Kimpo Air Base.
(Source: NMUSAF)

In contrast, the heavier Sabre enjoyed an advantage over the MiG in maximum dive speed, and its flight control system was considered superior. The Sabre also had faster firing .50-caliber machine guns, but the range was limited and the shells' destructive power, or lack thereof, left many aircrews longing for something that packed a bigger punch.[105] With its redundant flight control systems, "heavy armor plate, bulletproof glass, adequate cockpit pressurization and temperature controls," and other extravagances like better gunsights, Mahurin likened the Sabre to a well-appointed Cadillac; the MiGs were more like stripped-down Fords. "There were many times when we felt that we would rather be driving Fords," Mahurin recalled, "but every time one of our pilots brought a shot-up F-86 home for a safe landing we were damn glad we had the Cadillacs." Nevertheless, the majority of young

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during his tenure as commander of the Fourth, "almost 3/4 of my operating cost per month … was for the loss of these drop tanks and it is very necessary to drop these tanks whenever the MiG is contacted." Baker reported that his unit was expending external fuel tanks "at the rate of approximately 2500 per month."

[104] Zhang, *Red Wings over the Yalu*, 91; Futrell, *United States Air Force in Korea*, 403, 412, 421; Futrell, *USAF Operations in the Korean Conflict, 1 Jul 1952 - 27 Jul 1953*, 50–51; Schinz, "Brief Resume of the Experiences," 4; "Enemy Activity in Korea: Air to Air," November 15, 1952, II–9.

[105] Hone, "Korea," 469; Werrell, *Sabres Over MIG Alley*, 19–23; Y'Blood, *MiG Alley*, 33; Futrell, *United States Air Force in Korea*, 253, 651, 696–99; *FEAF Report on the Korean War*, II:173–74. Werrell notes that one Soviet ace "dismissed the American .50s as being like mere peas and told of MiGs returning to base with forty or fifty hits." To address the deficiency, FEAF conducted "Project Gun Val," discussed later in this chapter.

American pilots considered the MiGs superior to their Sabres in the high-altitude dogfights in MiG Alley.[106]

The Americans' first update to their Sabres, the F-86E, began trickling into Korea in mid-1951, slowly replacing the older A-models on a one-for-one basis. Vandenberg's October 1951 decision to reapportion Sabres from stateside bases to the war accelerated the E-model's combat fielding. Although the F-86E's arrival was applauded by the airmen, it retained the same A-model engine and was weighed down with 565 pounds of additional equipment, much of it due to the new A-1C(M) gunsight and its accompanying APG-30 radar. The Sabre pilots' demands for an aircraft that could match the MiGs' high-altitude climb and turn performance were not answered until the following summer when the first F-86Fs arrived, equipped with a new, higher-thrust engine and, more importantly, sporting a new wing design.[107] Armed with growing numbers of F-86Fs, the Americans in early 1953 finally achieved a technological advantage over their MiG-equipped adversary.[108]

But even prior to the combat debut of the F-86F, the Americans were schooling the MiGs in the air. Looking back on the war, Air Force officials were astonished at their success despite the seemingly insurmountable odds. Initial claims pegged the Americans' superiority at fourteen to one, later refined in FEAF's final *Report on the Korean War* to ten-to-one based on its count of "792 MiG-15's ... destroyed at a cost of only 79 F-86's."[109] When

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[106] Evans, *Sabre Jets Over Korea*, 109, 196–98; Werrell, *Sabres Over MIG Alley*, 88; Futrell, *USAF Operations in the Korean Conflict, 1 Jul 1952 - 27 Jul 1953*, 50–51; Mahurin, *Honest John*, 33–34, 37. Evans recorded in his diary entry dated October 30, 1951: "Again I say what an airplane that MiG is." *cf.* Smith to Commanding General, Far East Air Force, "Combat Evaluation of the MiG-15"; Hinton and Wingo, "Analysis of Operations at Kimpo," 29–31; Hinton, "MiG-15 Versus F-86A," 3–4; Hise, "F-86E versus MiG-15 in Korea," 1–5. The American press also published varying assessments of the F-86 versus the MiG-15; see, for example, "MIG's Top Sabres"; "Jet 'Superior to' MIG-15"; "Ramey Holds F-86 Better than MIG"; "Gabreski Tells Truman MIG-15 Is Good as F-86." Mahurin complained about the press reporting, noting that the "pilots' opinions" of the Sabre's deficiencies relative to the MiG were often "based on emotion and not on scientific fact."

[107] Jones to Commanding Officer, 4th Fighter Interceptor Wing, "F-86E Combat Evaluation"; Futrell, *United States Air Force in Korea*, 402; Werrell, *Sabres Over MIG Alley*, 24, 87–88. Jones reported: "The inability of the F-86A and F-86E to climb, zoom, out-turn, and accelerate with the MiG-15 at any altitude, particularly above 25,000 feet, makes the need for a greater power plant obvious. It is believed that the full combat potential of the F-86E cannot be realized until an engine of substantially greater thrust is installed."

[108] Futrell, *United States Air Force in Korea*, 509, 512, 651; Werrell, *Sabres Over MIG Alley*, 24–26; Futrell, *USAF Operations in the Korean Conflict, 1 Nov 1950 - 30 Jun 1952*, 122; Futrell, *USAF Operations in the Korean Conflict, 1 Jul 1952 - 27 Jul 1953*, 68–69; Baker, "Report on F-86 Operations," 5.

[109] *FEAF Report on the Korean War*, II:5, 8; Y'Blood, *MiG Alley*, 44. Officials at FEAF expressed their astonishment with their pilots' accomplishments: "That the United Nations was able to maintain air superiority over North Korea in the face of a modern air force, numerically superior, and enjoying immunity from attack over his bases or on the ground, is difficult to understand." The Korean War Sabre-MiG kill ratio continues to be a source of controversy, and it has been revised downwards on several occasions. *cf.* Futrell, *United States Air*

asked to identify the source of the American success, officials relied on a common refrain: the superior training, skill, and aggressiveness of American Sabre pilots.[110] That and their gunsights.

Although the assessments are usually caveated with the phrase "when it worked," several histories of Korean air combat and MiG Alley single-out the new A-1C(M) radar-gunsight combination as an important advantage for the Sabre pilots. For example, Werrell claimed that the Americans' "superior gunsight" was the "most significant" advantage "American pilots had over their Communist adversaries." Even FEAF's final report on the Korean War concluded that the "superior armament and fire-control system" was a critical component in the Sabres' "ten to one victory ratio" over the Communist MiGs.[111]

But victory in air combat in MiG Alley relied on many things besides just the "superior gunsight" or just the "aggressive" pilot. Only if the Sabre pilot's eyesight was good enough to detect the MiG; and if the MiG elected to give battle by descending to the F-86's altitude; and if the American pilot was skillful enough to maneuver his aircraft into position near the MiG; and if his radar tracked the appropriate target; and if the A-1C(M) computed the correct prediction angle; and if the Sabre's machine guns did not jam upon firing; and if there was some way to verify the MiG claim would the pilot have a good chance at returning home triumphant and adorning his aircraft with another red star. As before, the popular narratives conveniently overlooked this intricate chain of events that necessarily preceded a pilot celebrating a victory that night in the bar.

Capturing Glory

The day after he disembarked from his trans-Pacific troopship on June 6, 1951, Lieutenant Evans shuffled through his remaining in-processing requirements at the 4th's rear

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Force in Korea, 695–96; Werrell, *Sabres Over MIG Alley*, 141–43; Zhang, *Red Wings over the Yalu*, 201–4; Sayers, "Red Baron Reports."

[110] Evans, *Sabre Jets Over Korea*, 103; Peters, "Air Force, Korea, and Kosovo," 19; Thompson and Nalty, *Within Limits*, 28; Hone, "Korea," 468, 475, 488; Werrell, *Sabres Over MIG Alley*, 51, 79, 221; Futrell, *United States Air Force in Korea*, 246, 698–99; Crane, *American Airpower Strategy in Korea*, 89; Sherwood, *Officers in Flight Suits*, 77. Evans reflected on the Americans' success, "We have a damn fine plane but not the best on every point; what makes the difference is that our pilots are better by far." The obvious corollary to the favored rationale was the ineptitude displayed by the majority of the MiG pilots.

[111] Werrell, *Sabres Over MIG Alley*, 26, 32; *FEAF Report on the Korean War*, II:16. Werrell also suggested that "the poor marksmanship of the MiG pilots could be attributed to … an outdated gunsight." See similar assessments of the gunsight in: Sherwood, *Officers in Flight Suits*, 75; Thompson and Nalty, *Within Limits*, 28; Y'Blood, *MiG Alley*, 15; Wildenberg, "A-1C(M) Gunsight," 34.

echelon location at Johnson Air Base, Japan. The day's activities included attending a briefing offered by two Sabre pilots, both of whom had recorded a MiG victory. Evans emerged wide-eyed from the "well-organized lectures," noting in his diary, "From the sound of things so far, there are shades of Buck Rogers in this aerial war between the F-86s and MiG-15s."[112]

Powered by its 6,000-pound-thrust J-47-GE-13 jet engine, the Sabre burst into Korea with a roar. But other than the rumble of a jet engine replacing the whirl of a spinning propeller, and in the F-86E a small radar that automatically fed range information to a lead-computing gunsight, not much else had changed in the fighter world since the later stages of World War II. The machine guns still fired .50-caliber rounds. The radios were equivalent. The formations were similar, including their emphasis on the flight lead-shooter and the wingman-observer roles. And the individual battles bore a remarkable resemblance to those from earlier, for although the A-1 gunsight promised to let pilots attack from greater distances and with larger deflection angles, pilots still strove to catch their opponent unaware before firing from a close-range, six o'clock position. Combat in the newer jets was simply now conducted at greater speeds, higher altitudes, and with more forceful G-maneuvers. With a few months of combat under his belt, Evans concluded, "Dogfighting hasn't changed, basically—it's still a matter of seeing first and trying to get on the other's tail or shaking him off yours."[113]

In Korea, as in wars past, glory went to the individual pilot that pulled the trigger and sent an enemy aircraft spiraling to the ground. But despite the continued aura of simplicity and objectivity, victories in the air remained subject to interpretation and shrouded in uncertainty. Ostensibly a "pure meritocracy," the chance of earning glory was not equally distributed, bound instead in formations that were as much rooted in tradition as they were a product of tactical necessity. And air warfare between planes, although still celebrated as honorable and often depicted as relatively bloodless, remained as brutal, ruthless, and

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[112] Evans, *Sabre Jets Over Korea*, 11. Buck Rogers was a space-age, science-fiction hero popular in the 1930s and '50s.

[113] Ibid., 181. Hone, "Korea," 470–71. Hone's assessment echoes that of a 1952 report from the Fourth FIG, which stated: "Basic air to air fighter tactics used in Korea are fundamentally the same as they always were, except for certain modifications imposed due to high rate of fuel consumption, loss of visual acuity at high altitudes, and the much larger air space required for maneuver at high speeds." Hise, "F-86E versus MiG-15 in Korea," 5.

perilous as before. Nevertheless, bolstered by the official assessments that attributed the Sabres' success over the more numerous MiGs to the "well-trained, experienced and aggressive [American] pilots," the ace figure thrived in Korea.[114]

The Allure of Acehood

Evans was thrilled to be flying the F-86 Sabre. It was, he thought, "the hottest assignment in Korea," and he joked of the "jealous prop and straight-wing pilots" that only dreamed of mounting the sleek, swept-wing Sabre. Continuing the policy of the interwar years, the Air Force tended to send its best pilots to single-seat fighters, and by 1950, the Sabre was clearly at the top of the pecking order. In the words of Salter, only "those with the least élan would go to bombers and attack aircraft." Evans, validating his status as a Sabre pilot, proudly recalled one occasion when he and a flightmate traveled to Japan to pick up some new Sabres: walking through the operations building, "everybody just gaped in awe at us. After all, we were the only 86 Sabre outfit in the war, the big MiG hunters, and considered very hot stuff wherever we went—especially heading back for combat."[115]

While Evans may have overstated the reception he and his flightmate received, his story was not totally divorced from reality. Those flying the F-86 had by far the best chance at becoming ace celebrities. While there were handfuls of pilots in the F-84 and the F-80C, and even a few B-29 gunners, that successfully downed an enemy plane during the Korean War, there were only forty Americans who downed at least five, earning the timeless distinction of ace, and they all flew the F-86. Leading the charge was Captain Joseph McConnell with his sixteen victories. McConnell and the other top four aces combined for 72½ downed aircraft, nearly 10 percent of the total claims awarded to the Sabre pilots. Blesse quickly joined the ace ranks, eventually earning distinction as a double ace with ten kills. Mahurin, having flamed more than twenty enemy aircraft in World War II, came up two short of ace status during the Korean War, his attempts cut short by a sixteen-month stint as a prisoner of war (POW) in China after he was shot down on May 13, 1952. Evans too missed out. "Chick" Cleveland, then a lieutenant, didn't join "that elite group" of aces

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[114] Sherwood, *Officers in Flight Suits*, 94; *FEAF Report on the Korean War*, II:16.

[115] Evans, *Sabre Jets Over Korea*, 100, 138–39; Salter, *Burning the Days*, 88. On the hierarchy among different aircraft types and its role in Air Force pilot "elitism," see Sherwood, *Officers in Flight Suits*, 67.

until fifty-five years later in 2008, when access to Soviet records from the Korean War finally yielded confirmation of an earlier-deemed "probable" victory.[116]

As they had two wars before, the ace pilots captured the nation's attention. For example, *Life* magazine on July 7, 1952, proudly published the photographs of America's then-seventeen Korean jet aces, proclaiming them "a new and deadly addition to the ranks of air warriors."[117] Unlike in World War II, the fighter pilots in Korea no longer had to compete for top billing with the service's bomber pilots. North Korea's lack of suitable industrial targets meant that the bombers no longer traveled in awe-inspiring packs of hundreds, and their new missions to blow-up irrigation dams or drop napalm on villages as part of the limited "police action" left some feeling uneasy. Consequently, the Air Force decided to popularize the aerial conquests scored by its fighter aces and their sleek, jet-powered aircraft. Both offered a compelling story: the pilots once again in the romantic role of "aerial knight" dueling in the skies; their aircraft as testament to the vision of the new, future-minded, technologically savvy Air Force.[118] Adding more fuel to the "great pilot" narrative was the pilots' own stories of combat, the symbolism of the single-seat in their fighter plane, and the narrative that continued to emphasize the successful pilots' natural flying skills. The myth of the fighter pilot was alive and well.

For example, as their predecessors had done earlier, many Korean War pilots struggled to find an appropriate analogy to convey their experience of air combat. And as before, many pilots invoked sporting analogies, complete with connotations of sportsmanship and fairness. For example, Evans described the squadron operations building after one victorious mission as "a madhouse, ... like the locker room of the winning team of the game of the year. After that, who needs games?" Other pilots simply tried superlatives.

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[116] Maurer, *USAF Credits: Korean War*; Werrell, *Sabres Over MIG Alley*, 144; "Air Force Aces," 128; Haulman, "Aerial Victory Credits"; "American Fighter Aces." The aces in Korea accounted for 310½ of the Air Force's 896½ aerial victory credits. Werrell concluded that approximately "four percent of the pilots that flew Sabres in the Korean War accounted for forty percent of the victories." However, discrepancies over the number of aces and total victory counts exist among the cited sources, some due to Cleveland's late addition to the ace rolls. While the specific totals and quantities are subject to debate, the significant and disproportionate contribution of the aces to the victory totals is not. On Cleveland, see: O'Connor, "Board Recognizes Korean War Pilot as Ace Decades Later"; Bates, "Retired General Becomes Air Force's Newest Fighter Ace"; Trest, *Once a Fighter Pilot*, 88–90; Cleveland, Oral History Interview, 36–37, 39–40.

[117] "These Seventeen Americans," 35. *Life* included a special feature on the first jet ace, Major James Jabara, and the F-86 Sabre in its earlier editions: Dille, "Jets' First Ace"; "US Sabres Splash Red Jets."

[118] Sherwood, *Officers in Flight Suits*, 8, 73. On the other Air Force missions and their contribution to the air war, see: Werrell, *Sabres Over MIG Alley*, 3; Y'Blood, *MiG Alley*, 44. Hallion, "Korea: The Forgotten (Air) War," 2–3.

Blesse for one recalled his MiG battles as "the greatest thrill of my life"; "the intense, gripping anxiety and excitement that occurred when I saw some kind of movement which indicated the enemy pilot had seen me and one of us wasn't going home."[119]

Regardless of the chosen analogy, the experience of combat was for many Sabre pilots intoxicating. When faced with the choice of going home with only four kills or extending his tour, Blesse opted to extend, having been "caught up in the Ace syndrome long before I got to Korea." He added, "I wanted that fifth kill so bad I could taste it."[120] Cleveland twice opted to extend his tour hoping to get his confirmed fifth kill. Writing to his wife of his decision, he explained, "This is a lifetime experience—it is the best part of my Air Force life, by far the best—all flying after this will seem lackluster." When he nearly ran out of gas chasing his goal, Cleveland was finally ordered home by his commander, still one confirmed kill short.[121] Salter noted, "It was not duty, it was desire" driving the pilots. "Duty would not search with such avidity in the waning light, coming down the river one last time, the earth already in darkness that was rising slowly, like a tide, the heavens being the last to go."[122]

The single seat in the F-86 likewise continued to fuel the image of the individual ace-pilot capturing glory. As Boelcke had earlier, the pilots in the Korean War reveled in the status, responsibility, and independence they enjoyed as their aircraft's lone occupant. Mahurin proudly declared, "A jet-fighter pilot is responsible to himself alone."[123] Evans similarly recalled the "very personal relationship each fighter pilot must establish with a single-seater.[124] Salter most poetically captured the feeling of "spiritual isolation" common to single-seat fighter pilots:

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[119] Evans, *Sabre Jets Over Korea*, 157, 177; Mahurin, *Honest John*, 42, 44, 87; Blesse, *Check Six*, 65; Sherwood, *Officers in Flight Suits*, 79.

[120] Blesse, *Check Six*, 65, 69–70.

[121] Trest, *Once a Fighter Pilot*, 88–96; Blesse, *Check Six*, 69. Although missing the all-important fifth MiG kill, Cleveland had nevertheless racked up an impressive tally: four destroyed MiGs, four damaged MiGs, and two probable victories. Blesse referred to the young lieutenant as "'The Ivory Ace,' 99 44/100ths percent pure," mimicking the popular soap advertisement. Blesse helped get Cleveland inducted into the American Fighter Aces Association as an honorary member.

[122] Salter, *Burning the Days*, 153.

[123] Mahurin, *Honest John*, 30. Blesse expressed a similar opinion, observing after one eventful flight, "Relying on other people in this business can kill you." Blesse, *Check Six*, 47.

[124] Evans, *Sabre Jets Over Korea*, 13, 126, 195.

> You lived and died alone, especially in fighters. Fighters. Somehow, despite everything, that word had not become sterile. You slipped into the hollow cockpit and strapped and plugged yourself into the machine. The canopy ground shut and sealed you off. Your oxygen, your very breath, you carried with you into the chilled vacuum, in a steel bottle. If you wanted to speak, you used the radio. You were as isolated as a deep-sea diver, only you went up, into nothing, instead of down. You were accompanied. They flew with you in heraldic patterns and fought alongside you, sometimes skillfully, always at least two ships together, but they were really of no help. You were alone. At the end, there was no one you could touch. You could call out to them, as he had heard someone call out one day going down, a pitiful, pleading "Oh, Jesus!" but they could touch you not.[125]

Moreover, echoing the fighter pilot narratives of the past, the success of the ace-pilot in Korea, seated alone in his fighter aircraft and engaged in a contest likened to a sports match, once again appeared dependent upon his naturally endowed flying acumen. Many continued to believe that the necessary fighter pilot skills could not be taught, only refined. The prevalent attitude seemed confirmed when toward the middle of the war, shortages of fighter-trained pilots necessitated that the Sabre units start accepting "re-called reserve officers who had no fighter background." Colonel Gabreski, then commander of the 51st FIW at Suwon, complained that the new majors and lieutenant colonels constituted "a very serious problem" because they had "no desire to be fighter pilots, showed no enthusiasm for their work, and a few worked up fear of combat to the point that they were dangerous as a member of the combat team."[126] The 4th's pilots were more condescending in their assessment: "It is a waste of the government's time and money to take a 30 or 32 year old man whose service has been in troop transport or multi-engine flying, and attempt to train that man to engage in the highest form of aerial combat that has ever been developed."[127]

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[125] Salter, *Hunters*, 193. Salter's description was only the latest (and perhaps most eloquent) attempt at describing the feeling of flying a single-seat fighter. For example, a 1922 text on air combat offered the following: "The whole psychological medium differs. The pilot, even in formation, is an entity, controlling his machine by voluntary effort. True, he can see his comrades to right and left and observe the turn of the fight. But there is no elbow touch, no complete submergence of his own individuality in that of the mass." Milling, *Air Tactics*, VI–4. See also Sherwood, *Officers in Flight Suits*, 71.

[126] Gabreski, "(End of Tour) Report," 4. Schinz begged that the re-trained pilots not be sent to Korea until they had completed a year-long tour stateside. Schinz, "Brief Resume of the Experiences," 5.

[127] Hise, "F-86E versus MiG-15 in Korea," 22. The report noted, "We feel that it is almost an impossible task to take a pilot who flew transport or heavy bombers in WW II, who got out of the service and grew old mentally and fat physically for several years, recall that pilot, and expect him to fly a quick course in F-80s and become a replacement pilot for F-86 flying. In most cases it just simply won't work."

Evans for one thought that the "sport" of air combat demanded not training, but merely practice, "a constant honing of the edge—analyzing style, refining, polishing, dueling, *always* dueling—separating the pros from the amateurs."[128]

For many, the honing commenced immediately upon arrival in the theater. After Evans had finished his in-processing at Johnson Field, but before he went forward to his unit at Kimpo, he was thrown into "Clobber College," a semi-formal training regimen designed to prepare green replacement pilots for combat.[129] There, the new pilots flew as often as they could, gaining greater familiarity with the Sabre's performance in a variety of flight regimes. Combat demanded, they were told, an instinctive ability to fly "at all the edges of an airplane's envelope, as fast as you can go and as slow as you can go."[130] Despite having flown the Sabre before, Evans found himself "really working hard" after his second sortie, feeling "rather clumsy" and in need of "some more private sessions to properly manage the plane.... You just can't compress the time required to get a handle on the critical feel and control for sharp clean reaction so necessary in violent maneuvers."[131]

The emphasis in Clobber College was on practice and refinement. It included very little detailed instruction on the skills actually needed to score a victory in the air, but then neither did much of the Air Force's fighter training of the period. There was some gunnery training in the curriculum, mainly shooting at a banner that was towed by another aircraft along a preplanned course.[132] And there was occasional dogfight training, which emphasized aggressive, violent maneuvering and maintaining the offensive, six o'clock position. During these practice sorties, the green pilots often flew against a more experienced Sabre pilot who had briefly rotated to the wing's rear location; the new pilots were frequently clobbered by

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[128] Evans, *Sabre Jets Over Korea*, 235.

[129] Ibid., 13–28. References to the World War II incarnation of "Clobber College" can be found in Olds, *Fighter Pilot*, 124.

[130] Brown's comments are quoted in Hallion, "Air Dominance," 31. Olds described flying formation in the Sabre at 44,000 feet as requiring "total attention and a delicate hand on both stick and throttle." Olds, *Fighter Pilot*, 202.

[131] Evans, *Sabre Jets Over Korea*, 15.

[132] Cleveland, Oral History Interview, 26–27. Cleveland described the gunnery training: "The pilots in the fighters that were attacking [the banner] would come up 3,000 or 4,000 feet above it and off to one side of it and about even with it; turn into it, fly with it, and try to get the rag in the gunsight and shoot." On banner gunnery training, see "A-1 Sight and Air to Air Gunnery"; "Radar Ranging"; "Square Corner."

the combat veterans, giving rise to the name of the program.[133] But there was very little intersection between gunnery training and dogfight training.[134] Furthermore, there was minimal formal flight instruction included in the regimen, and any learning was largely gained through individual trial-and-error or through often-embellished stories told around the bar.

Nor was there any significant instruction during Clobber College on the pilots' aircraft or its new gadgetry, like radar-ranged LCGs. The lack of book-study reflected the pilots' predilections. They much preferred to spend their time either talking tactics or perfecting their dogfighting skills, things they thought would actually help them in combat.[135] Pilots needed to know how to max perform their airplanes relative to their adversary, but knowledge of how that performance was attained, either via hydraulically boosted flight controls or a radar-aided gunsight, was considered by many to be mere pedantry.[136] In fact, many pilots of the period boasted of their *lack* of knowledge of the aircraft they flew, thereby reinforcing the notion that good pilots were natural pilots, capable of flying anything with a set of wings.[137] Evans rationalized the pilots' nonchalant attitude, citing a World War I

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[133] Harbison recalled his experience in Clobber College, "I must say that I thought I was experienced on the F-86—and indeed I was—but [the combat experienced instructors] really flew that airplane to its limits, exploring corners of the envelope that I hadn't seen." Quoted in Hallion, "Air Dominance," 40. See descriptions of typical dogfighting training in Blesse, *Check Six*, 52–53; Blesse, Corona Ace Oral History Interview, 61–63.

[134] Later, Sabre units began experimenting with "camera gunnery," which combined gunnery training with dogfight training: the attacker didn't fire any bullets but instead recorded the engagement with his gun camera. Unfortunately, because the gun camera did not record the gunsight information, there was no way to validate whether or not the engagement would have been successful. See Meyer to Commanding General, Air Defense Command, "F-86 Activities Report"; Meyer to Commanding General, Air Defense Force, "F-86 Activities Report (Special)"; Schmid, "Operations of the 4th Fighter-Interceptor Wing"; Hesse, "Flying: Continuation Flying Training"; *History of the 334th Fighter Interceptor Squadron, Apr 1952*, 3.

[135] Risner, Oral History Interview, 26–27. Risner remembered spending hours discussing tactics, "where the MiGs were coming across the border, what altitude they were flying at, … what was the most effective and quickest way to get on the their tail."

[136] Obviously, the attitude was not shared by all. For example, Hagerstrom sought to prepare himself for Korean air combat by taking "courses over and over again on the A-4 gun sight" and reading "all the intelligence reports he could get his hands on." Sherwood, *Officers in Flight Suits*, 70.

[137] Werrell, *Sabres Over MIG Alley*, 58. Sometimes the exigencies of combat necessitated a brusque aircraft introduction. DeArmond recalled how he arrived in Korea having never flown the F-86; "in fact, I had never see one. Our captain stood on the wing of a Sabre, told me how to start it, and off I went. We got three or four rides, and I went into combat.… The first mission in combat, I was so 'clanked up' and so tight I couldn't remember where the gun switch was when we crossed the bomb line [into enemy territory]." Quoted in Hallion, "Air Dominance," 34. Recounting his tendency to jump in unfamiliar aircraft and take to the skies, Olds explained, "We didn't care much about the niceties of emergency procedures in those immediate postwar days, nor did we pay much attention to a lot of bothersome flight regulations either." Olds, *Fighter Pilot*, 96–99, 156–58.

French Air Force saying, "The pilot should not be overly familiar with the intricacies of his machine—it is apt to destroy his dash." Reflective of the prevalent sentiment among pilots, Evans opined: "My feeling is, if the pilot can't solve it or affect it from the cockpit, why clutter his mind with all that junk? Like the French saying infers: He may learn so much about what *might* happen that he's just as liable to get too smart to do this job—then what?"[138] Unfortunately, not all the pilots lived to regale their friends with tales of their machismo, instead becoming victims of their own bravado.[139]

Thus, young fighter pilots entering Korea still looked to the historic image and the myth of the fighter pilot—which again was not a purposeful misrepresentation of reality, but rather one stripped of nuance and contingency in favor of its message—as they sought to understand what an ace was and what it would take to become one. The service's ritualization of the myth and the corresponding "great pilot" narrative during its semi-formal instruction in programs like Clobber College exacerbated the confusion. Fighter combat, it was understood entering Korea, was a young man's sport that demanded quick reflexes, exceptional eyesight, and the brashness of youth, all of which were known to degrade with age.[140] With their finely honed flying skills paired with a ferocious and aggressive attitude, pilots planned to pounce on their foe and deftly maneuver their aircraft into a position to flame their Communist enemy.

Manufacturing the Ace

The Air Force's first jet ace, Captain (later Major) James Jabara, didn't fit the typical mold of the successful fighter pilot. Born in 1923 and a veteran flyer from the Second World War, Jabara was "short," "had weak eyes," and smoked "a dozen cigars a day." He was aggressive though, a "feisty fellow" and a borderline "discipline problem" in the words of

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[138] Evans, *Sabre Jets Over Korea*, 160, 170, 228. Recall that the air services had earlier encouraged this ambivalence towards the pilot's aircraft; see Rippon and Manuel, "Report on the Essential Characteristics," 412.

[139] Werrell, *Sabres Over MIG Alley*, 58; *Summary of F-86E Aircraft Accidents*, 2–3. Air Force safety officials ultimately concluded that from January 1951 through August 1954, "pilot error" was the "most frequent primary cause factor in F-86E accidents," and "in the majority of cases, improper operating procedure was the first step in the sequence of events leading to the accident."

[140] "How Old Can You Jet?". The Surgeon General of the Air Force had recently issued a report concluding that "the combat utilization of pilots for jet type aircraft ceases at age 30, and for conventional [prop] type fighter aircraft at age 32." The experience of World War II seemed to confirm the assessment, with men between the ages of twenty-one and twenty-six reportedly making the best fighter pilots; see the assessment in "Tactics: V & XIII Fighter Commands," 5.

the 4th FIW's commander, Colonel John Meyer, himself the seventh leading American ace from World War II with twenty-four kills. Meyer also described Jabara as a "hot shot Charlie type … who sang the loudest in the club and made more noise than the other people and dressed on the extreme side for the military." But when the Air Force "was pushing to get an ace," and officials at Fifth Air Force in Japan spurred their subordinate flying commanders to hurry along the process, Jabara had already distinguished himself with two MiG kills. Hence, Meyer identified Jabara as "the most likely candidate" for acehood. From then on, Jabara flew only the best missions that had a high likelihood of encountering MiGs, and he always flew as the flight lead to maximize his chances at downing a MiG. After having earned four kills but while still chasing the elusive fifth, Jabara was granted special permission to remain in Korea flying missions even after his squadron had rotated back to the Wing's rear echelon base.[141]

Jabara also earned a reputation as a flight lead not particularly interested in his wingman's well-being. When wingman were lost to the MiGs—a recognized risk of combat—most flight leads expressed anguish. For example, Mahurin wrote that he "was crushed" after one of his wingmen was shot down.[142] Pilots flying on Jabara's wing weren't so sure that the cocky flight lead was looking out for them. One, Bruno Giordano, complained that Jabara cared "less about what happened to his wingman and more than once put them in harm's way." For example, during his celebrated ace mission, Jabara and his wingman became separated. Jabara subsequently explained that it was due to differences in aircraft performance, but others suggested that Jabara's wingman got "jumped by MiGs." In either instance, Jabara elected to press on alone, leaving his wingman to scrap for himself.[143]

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[141] Werrell, *Sabres Over MIG Alley*, 152–55; Dille, "Jets' First Ace"; Meyer, Oral History Interview; "Jabara: Image Search, 040131-F-0000G-004.jpg." The Air Force's official website includes several pictures of Jabara. All include a similar account of the popular narrative in the caption: "Jabara was the prototypical fighter pilot, although perhaps not at first glance. Standing 5 feet 5 inches tall, Jabara was nevertheless larger than life. He was determined to enter pilot training, and he did. He was equally determined to become an ace in his F-86 Sabre, and he did."

[142] Mahurin, *Honest John*, 49, 52. Mahurin's anguish was as much for his wingman as his own reputation. "I was crushed because I hated to establish myself as a guy who had no concern for others in his flight." Blesse took pride in the fact that he had only one wingman "who didn't come back in his own aircraft." Blesse, *Check Six*, 72.

[143] Dille, "Jets' First Ace," 139. Dille's account of Jabara's engagement is interesting in its description of the lost wingman, posing it as a testament to Jabara's fighting spirit rather than a breakdown in the established formation team: "Jabara climbed through this melee, back up to 20,000 feet, where he spotted six more MiGs.

Despite the hidden drama, Jabara became an instant celebrity when he downed his fifth and sixth MiGs on May 20, 1952. Most of the nation's leading newspapers featured history's first jet ace, accompanied by his photograph, on the front page. Readers were treated to Jabara's own description of the impressive dual victory, told "in his usual calm manner," *New York Times* editors noted, "as though he were discussing a duck hunt." Jabara recalled: "I tacked on to three MiG's at 35,000 feet and picked out the last man and bored straight in.... The MiG burst into flames.... Just as the pilot bailed out the MiG disintegrated. Then I climbed back to 20,000 feet to get back in the battle. I bounced six more MiG's. I closed in and fired two bursts.... When my second burst caught him square in the middle he burst into flames and fell into an uncontrolled spin. All I could see of him was a whirl of fire." Although Jabara's account of "bor[ing] straight in" on the "last man" doesn't elicit the image of gallant, fair play usually featured in the standard air combat script, the narrative still reflected the common image of bloodless victory. The news reports included with the description of Jabara's victories the standard air combat tally: "No American planes were lost in today's action that brought the Fifth Air Force's score against the Red jets in air-to-air combat to 49 destroyed, 12 probably destroyed and 124 damaged."[144]

The next day Jabara was spirited out of combat and into the hands of the Air Force's public relations officials. The sudden move resembled the German Kaiser's 1916 decision to ground Boelcke, worried that the ace's death would damage national morale. From there, Jabara returned home before being dispatched on goodwill tours to the Middle East and Europe. He was regularly trotted out for public appearances, including to receive a Distinguished Flying Cross in front of 20,000 Red Sox fans at Boston's Fenway Park.[145]

But Jabara's wing man was not with him. Kemp had tangled with some MiGs on the way up. Few pilots would consider tackling a flight of MiGs without a wing man to keep an eye out while he is shooting. But Jabara bore in on one of his newfound MiGs anyway." Later in the war, Jabara accidently shot down his wingman, Richard Frailey, in the commotion of battle. Werrell, *Sabres Over MIG Alley*, 121–24.

[144] "World's First Jet Ace Downs 2 MIG's Within 10 Minutes"; "Two New 'Kills' Give Yank Title of First Jet Ace"; "Kansan Becomes History's First Jet Fighter Ace"; "Kansan Downs 2 MIG Planes." The editors at *Life* devoted six pages to Jabara in its first issue after his achievement: Dille, "Jets' First Ace." As expected, *Air Force* also devoted several pages to Jabara in its June edition, including a self-authored piece: Jabara, "We Fly MiG Alley." Curiously, all the newspapers claimed that Jabara was an ace in World War II, yet the Air Force record only credits him with 1½ kills, a discrepancy possibly stemming from the temporary policy during World War II of awarding credit for enemy aircraft destroyed on the ground; see Haulman, "Aerial Victory Credits." Furthermore, with new access to Russian archival materials, Jabara's claims and his status as the first jet ace have come under increased scrutiny; see Werrell, *Sabres Over MIG Alley*, 154.

[145] "Jet Ace Out of Combat"; "Jabara, Jet Ace, Set for Mid-East Good Will Tour"; "Ace to Tour Jet Bases"; "First Jet Pilot Ace Back from Europe, Middle East"; "Fenway Crowd Sees 1st Jet Ace Awarded DFC."

After Jabara captured headlines, the nation's papers regularly updated readers on the ensuing race to become America's Ace of Aces in Korea. "13 Red Jets Shot Down in 2 Battles," trumpeted the December 14, 1951, edition of the *Washington Post*, "the greatest all-jet victory of the war." The action, reported the paper, also marked a "new record for United States jet pilots," with Major George Davis accumulating credit for "12 planes shot down in 16 days."[146] When Colonel Royal Baker, the commander of the 4th FIG from mid-1952 through early 1953, surpassed Davis as the top ace, the *New York Times* deemed the news front-page worthy.[147] Manuel Fernandez's and McConnell's tenures as Ace of Aces received similar coverage.[148] Most of the news stories included the thrilling details of the victorious air battles. After devoting precious paragraphs to the enthralling tales of "furious dogfights" in which "Sabre jet pilots blasted ... MIGs out of the northwest Korean skies," the newspapers had only a few lines remaining at the bottom of the column to report on the ground action. For example, after devoting fifteen paragraphs to McConnell and the air battle over Korea, the *Chicago Daily Tribune* summed up the action on the ground in a single sentence: "Ground fighting raged for the third day near outpost Horseshoe—a bend in the Pukhan river along the east-central front."[149]

But, the pictures of the aces in the papers belied the image of the stereotypical fighter pilot. These celebrated aviators were not the usual young twenty-somethings characteristic of prior wars, but were instead often pushing thirty or beyond. Some called them the "'old pros' of MiG Alley."[150] Of the forty Korean War aces, one shy of half were field-grade officers holding ranks of major, lieutenant colonel, or colonel, and four of the

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Arguing "I don't think I've done my fair share.... I want to go back to complete my tour," Jabara eventually made his way back into combat. He would finish the Korean War as the second leading American Ace with fifteen kills, and as Meyer noted, he had mellowed considerably during his second tour, becoming "very stable and mature." "First Korean Jet Ace Eager to Fight Again"; "Jabara to Fight Again"; Meyer, Oral History Interview.

[146] "13 Red Jets Shot Down In 2 Battles; Ace Gets 4."

[147] Parrott, "Sabres Bag 6 MIG's." Davis's MiG tally ended at fourteen after he was shot down, which also earned a front-page story: "Top U.S. Jet Ace Lost In Korean Air War."

[148] "Fernandez Bags 13th MIG, Becoming the Top Jet Ace"; "First Triple Jet Ace Helps Bag 9 MIGs." The news reports in particular emphasized the race between McConnell and Fernandez. For example, the *Chicago Daily Tribune* reported that "McConnell ... edged out Capt. Manuel Fernandez ... for the coveted first triple jet ace rating. Fernandez spurted ahead yesterday when he got his 14th MiG after McConnell had pulled even at 13 earlier this day."

[149] "First Triple Jet Ace Helps Bag 9 MIGs."

[150] "'Old Pros' of MiG Alley."

eleven top scorers had also claimed victories in the prior world war. A veritable fighter pilot dinosaur, Lieutenant Colonel Vermont Garrison scored his fifth jet victory after his thirty-seventh birthday—he would go on to score five more and became a double ace in Korea.[151] In contrast, field-graders in World War II accounted for less than a quarter of the confirmed kills.[152] One FEAF study tasked with investigating the demographics of successful fighter pilots in Korea concluded that "some 68 percent of pilots who had destroyed MiG's were over twenty-eight years old, while 67 percent of the pilots who had scored no kills were less than twenty-five years old."[153] Another FEAF report noted the apparent contradiction: Korea showed that a pilot's "maturity, judgment, and experience," not "youth with its attendant peak physical condition," were "of greater concern in modern jet warfare."[154]

Perhaps a more significant influence on the disproportionate success of the senior aviators, rather than just the introduction of "modern jet warfare," was that for the first time in American history, the US military could take advantage of a large cadre of older, seasoned fighter pilots at war's outset, men who not more than a decade earlier had proven their mettle battling German Messerschmitts and Japanese Zeroes. Harbison noted that in Korea, "most of the people were World War II veterans."[155] Another pilot explained that, consequently, these veteran fighter pilots had already learned the importance of aggressiveness and "fly[ing] to the sound of the guns."[156] Equally if not more important,

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[151] Futrell, *United States Air Force in Korea*, 655; "Air Force Aces," 128–29.

[152] "Air Force Aces," 122–28. But indicative of what was to be finally learned in Korea, almost 50 percent of the *top* World War II aces scoring fifteen or more kills were field grade officers.

[153] Futrell, *United States Air Force in Korea*, 698.

[154] *FEAF Report on the Korean War*, II:7. Another report noted, "Pilots who fought in every theater in WW II generally agree that the combination of high speed and inability to see far enough at altitude create a fighting situation that requires more judgment and skill than any other air-to-air fighter flying they have experienced." Hise, "F-86E versus MiG-15 in Korea," 17.

[155] Quoted in Hallion, "Air Dominance," 41. Discussions of pilots' age and experience can also be found in: "First Korean Jet Ace Eager to Fight Again"; Gabreski, "Our Top Ace Talks Shop," 41; Jabara, "We Fly MiG Alley," 65; Dille, "Jets' First Ace," 135; Thyng, "Operation of the 4th Fighter Wing in Korea," 2.

[156] Quoted in Hallion, "Air Dominance," 44. Brown observed, "One ace is worth a whole lot of journeyman fighter pilots.... They have a great sense of situational awareness." Spick identified *situational awareness*—"the ability of the pilot to keep track of events and foresee occurrences in the fast-moving, dynamic scenario of air warfare"—as the "mysterious ingredient" in successful fighter pilots, the "Ace Factor." Spick, *Ace Factor*, vi. Situation awareness has also "entered the mainstream of human factors" research; see for example Wickens, "Situation Awareness."

however, these older and more experienced pilots always flew in the all-important flight lead-shooter position in the fighter formations.[157]

New Tactics, Old Formations

Initially, the fighter pilot veterans tried to carry their tactics from World War II over into the jet age. Their formations proved semi-compatible, but not their bomber-escort tactics. One problem was the Sabre's appetite for jet fuel. Like most early jet aircraft, the Sabre consumed a prodigious amount of fuel at low altitude, which made it impractical to waste time forming up into massive forty or fifty-aircraft formations like the pilots had done before in the P-47s and P-51s. The Sabre's high fuel consumption and limited supply also reduced the time it could devote to protecting the slow-moving bombers. The pilots tried to address this limitation by flying at extremely high altitude and slow airspeeds, but that left them at a significant speed disadvantage and potentially far out of the fight if a pack of MiGs suddenly appeared, diving on them or the bombers. Moreover, unable to draw the MiGs to battle, the Sabre pilots found it impossible "to predict where or when the MiG would strike next," which in turn made it "difficult to place our large formations in the right place at the right time." In the end, the 51st FIW's tactics manual concluded that the "World War II fighter sweep practices … restricted both the exploitation of the tactical advantages of the Sabres, and the aggressiveness of the personnel operating them."[158]

The Sabre pilots consequently developed a new tactic, which they described as "offense in depth" and labeled the "jet stream." Rather than launch all the Sabre aircraft *en masse*, individual four-ship flights were launched at short, specified time intervals to provide in aggregate a constant presence over the target area as the B-29 bombers, or later the F-84 fighter-bombers, cycled through. If a Sabre flight spotted any MiGs, then in theory the flight

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[157] Werrell, *Sabres Over MIG Alley*, 137. Werrell figured that pilots flying in the lead position "registered 82 percent of the total MiG claims, a percentage that varied little over the course of the war." Additionally, "the men who finished as aces scored most of their kills as leads, 93 percent compared with 75 percent of those pilots who scored but did not tally five kills." See also discussion on flight position and probability of claiming a kill in Youngling et al., *Feasibility Study to Predict Combat Effectiveness*, 1–8–10, 3–3–5, 3–12–14.

[158] Futrell, *USAF Operations in the Korean Conflict, 1 Nov 1950 - 30 Jun 1952*, 111–12; *4th FIG Tactical Doctrine*, December 28, 1952, 7; *Resume of Our Tactics*, 4; Mahurin, *Honest John*, 45; Thyng, "Operation of the 4th Fighter Wing in Korea," 3, 7, 10; Hinton, "MiG-15 Versus F-86A," 19–21; Hise, "F-86E versus MiG-15 in Korea," 19; *FEAF Report on the Korean War*, II:7–8, 11. Complicating matters, the Sabre pilots frequently had issues communicating with the B-29s bombers; see: Gray to Commanding General, 5th Air Force, "Transmittal of Pilot's Statements"; Beckwith to Commanding Officer, 4th Fighter Interceptor Wing, "Analysis of Aerial Engagements, 23 Oct 1951."

leader could quickly summon the other airborne F-86s to the battle using the radio. Boasting of the new tactic, the pilots in the 51st declared, "With each flight responsible to itself, these highly mobile, maneuverable, self-supporting forces that can slash at formations of the enemy with relative impunity, have increased the normal aggressiveness of the individual Sabre pilot."[159]

Unlike the escort tactics which required modification, the Sabres' formations themselves, and the responsibilities specified therein, remained remarkably unchanged from those used during the last three decades. All of the aircraft in the formation were there primarily to support the flight lead flying in the Number 1 position. As the most experienced pilot, he was responsible for leading the formation to and from the patrol area, and if MiGs were detected, he would decide if, when, and how they would be engaged. The 4th's tactics manual noted that the flight leader "must be able to think alone, possessing that essential ability of being able to assess a combat situation quickly and accurately. He must be aggressive or all his other capabilities are wasted." [160]

The second-most experienced aviator flew in the Number 3 position as the element lead. Together, the two leaders (flight and element) were designated the "gunners" or "shooters" in the formation. The element leader's job was to protect the flight leader by maneuvering to thwart any potential enemy attack, "thus allowing the lead element that period of time necessary for the destruction of the aircraft he [*sic*] is attacking." Initially during the war, the element leader flew 250 feet away from the flight lead, but later he was granted more flexibility and instructed to fly "500 to 1,000 feet above the leader and at any position out and in back of the lead element where he can provide the best possible coverage."[161]

Both leaders had a wingman assigned to them. As "the subordinate member[s] of the team," the wingmen served as "protectors" or "lookers" for their leaders, leaving the more

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[159] *4th FIG Tactical Doctrine*, December 28, 1952, 7–9; *Resume of Our Tactics*, 7, 12–13; *FEAF Report on the Korean War*, II:8–9; Futrell, *USAF Operations in the Korean Conflict, 1 Nov 1950 - 30 Jun 1952*, 112; Hinton, "MiG-15 Versus F-86A," 20–21; *4th FIG Tactical Doctrine*, December 28, 1952, 23.

[160] *4th FIG Tactical Doctrine*, December 28, 1952, 16–17.

[161] *Resume of Our Tactics*; *4th FIG Tactical Doctrine*, July 22, 1951, 9; *4th FIG Tactical Doctrine*, December 28, 1952, 16–17; *4th FIG Tactical Doctrine*, June 17, 1953; Hise, "F-86E versus MiG-15 in Korea," 11; Hinton and Wingo, "Analysis of Operations at Kimpo," 20. By 1953, the Fourth Wing allowed its element leader to fly "approximately 400 yard[s] out, slightly back and stacked either slightly below or slightly above the lead element, depending largely upon the position of the sun."

experienced pilots free to concentrate on gunning down a MiG. The wingman's "sole duty is to assure his element leader security and freedom of action for initiating and completing attacks," the 4th's tactics manual explained, and the wingman consequently provided "approximately 75-80 percent of the defensive observation" for the flight. If a wingman detected a threat, he was told to tell his leader but to never leave the formation to hunt it down; he needed "to stick like Scotch tape to his leader." Consequently, a wingman rarely fired his guns.[162]

The wingman's position nearby his leader, initially only 150 to 200 feet besides and slightly aft, but later extended to 200 to 300 feet, left him functioning essentially as a shield since any MiG bullets would likely need to pass through him before they reached the leader (figure 3.19). However, the tight positioning—close enough to read the stenciled numbering placarded on the leader's fuselage—also minimized the chances of the formation being suddenly thrown apart with one abrupt maneuver by the flight lead. If the flight members did get split up, the pilots were instructed to "get the nose down, the Mach up, and the hell out of the area"; and if they all made it back to base, the wingman could expect to receive a good dressing-down.[163] Additionally, the close formation placed the wingman in a position where he could immediately transition to the offensive if his leader directed, for instance if the leader's guns suddenly jammed or if he ran out of ammunition.[164]

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[162] *Resume of Our Tactics*; *4th FIG Tactical Doctrine*, July 22, 1951, 9; *4th FIG Tactical Doctrine*, December 28, 1952, 16–17; *4th FIG Tactical Doctrine*, June 17, 1953, 15–17; Hise, "F-86E versus MiG-15 in Korea," 11; Hinton and Wingo, "Analysis of Operations at Kimpo," 20; Stocker, "Wing Man Has to Have Eyes," 32.

[163] *Resume of Our Tactics*, 13; Hinton, "MiG-15 Versus F-86A," 16; Hise, "F-86E versus MiG-15 in Korea," 11; Mahurin, *Honest John*, 50. Complaints about wayward wingmen are a staple of Korean pilots' memoirs; see, for example: Blesse, *Check Six*, 62; Evans, *Sabre Jets Over Korea*, 186; Sherwood, *Officers in Flight Suits*, 87–88; Salter, *Hunters*, chap. 19.

[164] *Resume of Our Tactics*; *4th FIG Tactical Doctrine*, July 22, 1951; *4th FIG Tactical Doctrine*, June 17, 1953; Hise, "F-86E versus MiG-15 in Korea," 11; Blesse, *Check Six*, 59; Blesse, "No Guts, No Glory," 10–12. There were three reasons for a wingman to fire on a MiG: to save his flight lead; if his flight lead ran out of ammunition and directed him to; or if he was conveniently aligned and could do so while still protecting his flight lead; see descriptions of each in: "FEAF Intel Form 1, 11 Jul 1951"; "Enemy Activity in Korea: Air to Air," October 25, 1952, II–4; Howard et al., "FEAF Intel Form 1, 16 Oct 1951 (0401)." For a brief period, the Sabre pilots experimented with 6-ship flights, but they soon abandoned the formation as too unwieldy; see: Futrell, *USAF Operations in the Korean Conflict, 1 Nov 1950 - 30 Jun 1952*, 112; Hise, "F-86E versus MiG-15 in Korea," 11; *4th FIG Tactical Doctrine*, July 22, 1951, 18; Hinton, "MiG-15 Versus F-86A," 16.

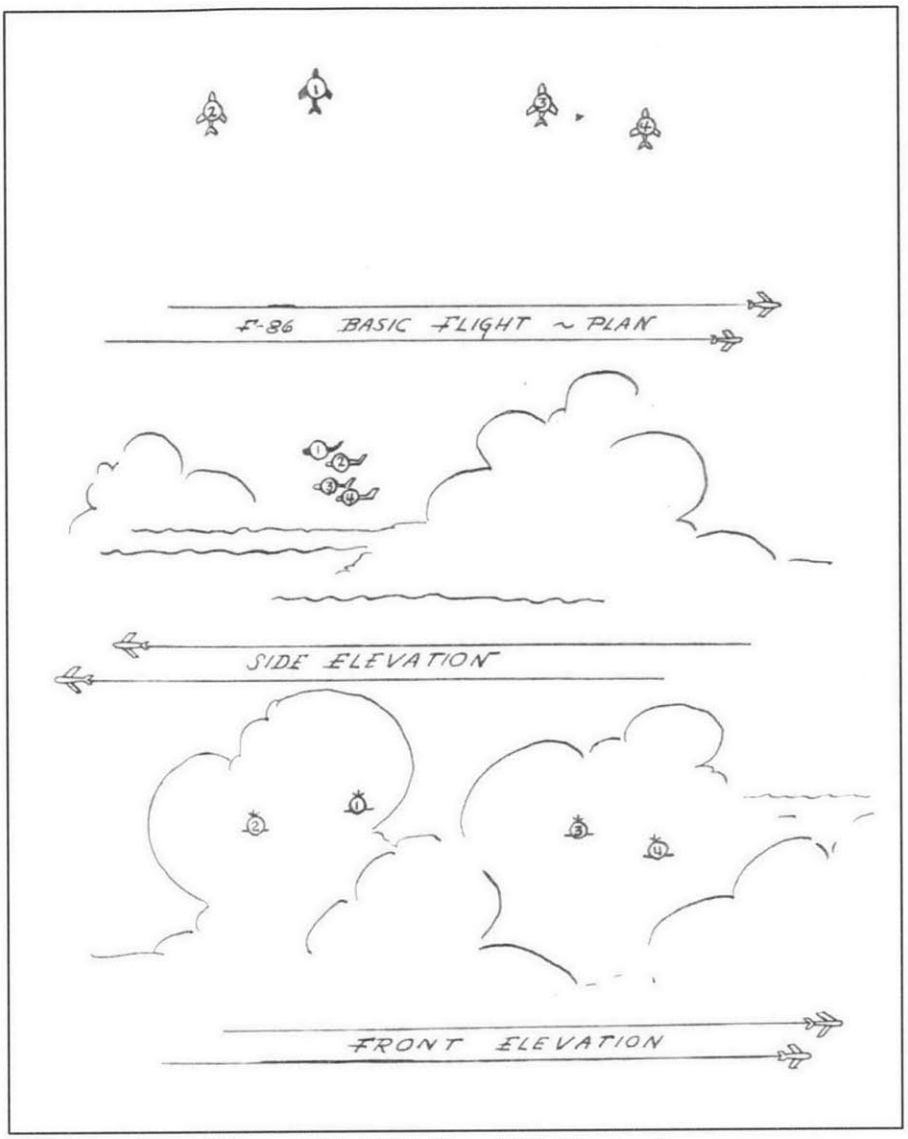

Figure 3.19. F-86 Four-Ship Formation.
(Source: Hise, "F-86E Versus MiG-15 in Korea," 13)

Hence, the wingman had the difficult task of constantly looking around outside for additional MiG threats while simultaneously following an aggressively maneuvering leader chasing after a wild and unpredictable MiG target. "Watch the leader. Watch out for bogeys. Turn and look. Turn and look. That's the very fabric of survival," the wingman were told. Acknowledging the wingman's difficult task, the 4th's tactics manual observed, "It takes a cool, determined, reliable, skillful pilot to fly wing on a good flight commander."[165]

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[165] *4th FIG Tactical Doctrine*, July 22, 1951, 9; *4th FIG Tactical Doctrine*, December 28, 1952, 16–17; Hinton and Wingo, "Analysis of Operations at Kimpo," 20; Salter, *Burning the Days*, 144; Mahurin, *Honest John*, 49; Stocker, "Wing Man Has to Have Eyes," 35.

One author likened the wingman experience to being "blooded," explaining, "You can't be a good leader … until you've flown wing." Lacking any formal combat training to prepare the young pilots for eventual element and flight lead responsibilities, the wingman role in the formation allowed the junior pilots to mature alongside more experienced leaders. Through "every day training, precision, and strongly supervised and standardized formations and procedures," the 4th's tactics manual noted, the wingman learned how to strike the tenuous balance between "sufficient discipline" and "individual initiative" needed in combat flight leaders. It could be a trying experience, Mahurin noted, but a wingman "takes solace in the fact that one day he will be a leader."[166]

The junior fighter pilots also quickly learned that it took more than just flying ability to impress their commanders and graduate to the vaunted position of element and later flight leader. A wingman's responsibilities to his flight leader did not end when the jet engines stopped spinning and the canopies opened. For example, William Brown recalled running errands around the base for his leader. Other times, when the wingmen were sent to Japan to retrieve an aircraft that had been undergoing repair, there was a clear expectation that upon their return, their flight suits pockets better be bulging with the fifths of liquor needed for the evening's martini-drinking contest.[167] Cleveland was tasked with building his squadron's ping-pong table.[168]

In retrospect, it is clear that the Sabres' formation was more than just a tactic for use in air combat. It represented a tool for the senior pilots to maintain control over the community, to garner glory for themselves by capitalizing on the flight lead-shooter position, and, most importantly, to imbue in their community's newest members the treasured fighter

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[166] Stocker, "Wing Man Has to Have Eyes," 35; Mahurin, *Honest John*, 49; Giraudo, Oral History Interview, 85–87; *4th FIG Tactical Doctrine*, July 22, 1951, 1, 2, 9. After having progressed to element lead, Evans had no desire to fly as a wingman again. But on one mission, his squadron was short of aircraft and in the hasty reorganization of the flight, he remarked, "I ended up on wing again--*#*&%*!!" Evans, *Sabre Jets Over Korea*, 92. Hutchins noted that the alignment of career paths tends to follow the "path of information through the system." Hutchins, *Cognition in the Wild*, 274.

[167] Sherwood, *Officers in Flight Suits*, 125–26; Hallion, "Air Dominance," 30, 34; Evans, *Sabre Jets Over Korea*, 105. Alcohol is a central component in most Korean fighter pilot memoirs. According to one fighter pilot cited by Sherwood, "Korea was the easiest place in the world to become an alcoholic." Many Sabre pilots flew drunk or still suffering the aftereffects of the previous night's boozing—the effects of alcohol on aerospace physiology, or even driving a car, had not yet been thoroughly studied. For example, DeArmond was shot down when his flight lead, who had won the prior night's martini drinking contest, failed to turn tight enough when his formation came under attack.

[168] Sherwood, *Officers in Flight Suits*, 125; Blesse, *Check Six*, 60–61. Cleveland promptly schooled the squadron pilots in ping-pong, all except for Blesse.

pilot spirit. Serving as a wingman in a combat unit became a rite of passage that one had to endure before being admitted into the fighter pilot fraternity. Most young lieutenants accepted their place at the bottom of the fighter pilot social order; as Sabre pilots, they were still thankfully well above all other aviators.[169] However, the "re-called reserve officers" weren't so enthusiastic about starting out again as lowly wingmen along with the junior-ranked pilots, and their reluctance to adhere to the fighter community's norms was one reason for the disdain shown them.[170]

The significance of the wingman position as a social element in fighter pilot life was also thrust to the forefront whenever a wingman somehow betrayed the experience and began garnering kills, and consequently glory, before he had completed the prescribed initiation. For example, the prime protagonist in Salter's *The Hunters* is not a MiG, but rather a "pale lieutenant" named Ed Pell who, after successfully downing a MiG, demonstrates a penchant for seeking glory at the expense of protecting his flight lead.[171] Salter based the character on Lieutenant James Low, who, like the fictional Pell, lost his flight lead and then shot down a MiG. Low's flight lead was almost shot down in the ensuing melee and the situation caused quite a stir among the squadron pilots. With only one month of combat time in Korea, Low noted, "I got lost and I got screwed up. I knocked an airplane down; I guess that vindicated me, but it wasn't my choice." Yet Low continued to rack up the victories, becoming an ace only six months after finishing flight school. He also kept mysteriously losing his teammates—his flight lead when flying as a wingman, his wingman when flying as a flight lead. Some in the squadron wanted him grounded. Others reportedly threatened court-martial. But, as Blesse noted, it was "difficult to discipline a guy that comes back with a kill, even though he's broken the rules."[172]

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[169] Hallion, "Air Dominance," 41. Commenting on the young lieutenants, Harbison noted, "very soon they caught the fever." On the opinions of the young pilots, see Gabreski, "(End of Tour) Report," 4; Schinz, "Brief Resume of the Experiences," 2; Thyng, "Operation of the 4th Fighter Wing in Korea," 2. Most agreed with Thyng's assessment, which read, "They are young, they are good, they are able, … they are eager, courageous, and the United States Air Force has no worries about this young generation."

[170] Gabreski, "(End of Tour) Report," 4. For example, Gabreski also complained that the "senior officers made very poor wingmen … and certainly they could never act as an example or an inspiration to the young 2d Lts."

[171] Salter, *Hunters*, chap. 19.

[172] "Pilot Is 17th U.S. Jet Ace In Only 6 Weeks in Korea"; Dorr, Lake, and Thompson, *Korean War Aces*, 61; Werrell, *Sabres Over MIG Alley*, 180–1; Gabreski, "Our Top Ace Talks Shop," 37.

These deeper social implications embedded within the pilots' formations and their influence on the fighter pilot community went unappreciated at the time. Lining up in formation at the end of the runway, ready to blast off toward MiG Alley, the pilots' minds were fixed solely on the task at hand. And for that task, the tactics and the formations were well-suited for the ensuing battle. As members of the 51st FIW declared, armed with the "jet stream tactic" and arranged in "fluid four" formation, the flight leader enjoyed "unlimited freedom in maneuvers" and could execute "high speed tactics" with "absolute confidence that his wingman and element will remain with him to support his fire.... This formation makes a 'bounce' on an enemy as simple as is possible."[173]

Battling the MiGs

To execute a bounce, the Sabre pilots first had to detect the enemy MiGs using their "Mark I eyeball."[174] Visually searching for the MiGs was tiresome and strenuous. Pilots had to constantly refocus their eyes out to infinity and slowly, methodically scan each sector of the sky, searching for any tiny black specks that might be far-off MiGs or any glints of sunlight that might be reflecting off a distant enemy's wing.[175] The task was made more challenging in Korea by the Sabre's near stratospheric patrol altitudes, which reduced the

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[173] *Resume of Our Tactics*, 6–7. See also the Fourth's appraisal of the tactic: *4th FIG Tactical Doctrine*, December 28, 1952, 16–17.

[174] Futrell, *United States Air Force in Korea*, 423, 514; *4th FIG Tactical Doctrine*, December 28, 1952, 10–11. Hallion, "Air Dominance," 47. Beginning in late 1952, the Americans were able to use a radar and tactical air-direction center on tiny Cho-Do Island, some 140 miles northwest of Seoul in the Yellow Sea, to help alert them to any nearby MiGs. The Cho-Do station, using the callsign "Dentist Charlie," could also provide Sabre pilots with the same detailed, GCI instructions that the MiG pilots had been enjoying for months. Prior to the emergence of Dentist Charlie, F-86 pilots received only occasional alerts of airborne MiGs by radar operators stationed at Kimpo, callsign "Dentist," but the radar coverage and reliability was marginal.

Beginning in May, five months before the UN radar installation at Cho-Do was fully operational, American intelligence officers and ground controllers began eavesdropping on the MiGs' inflight communications, which allowed them to alert the Sabre pilots to the MiGs' intentions. The Americans were able to glean significant tactical warning from the radio transmissions because that same month, the Chinese began providing detailed GCI instructions to some of its MiGs. The Americans' "electronics assistance" mimicked the "Y-service" that was used heavily by the Allies in the later stages of World War II. On Y-Service in World War II, see Mahurin, *Honest John*, 58–67; "Tactics and Techniques of Long-Range Fighter Escort," 17.

[175] Beeson, "Capt. D.W. Beeson," 71; *FEAF Report on the Korean War*, II:7. Beeson offered a good description of the importance and mechanics of visual detection. FEAF echoed the earlier assessment, noting that in Korea, "To see the enemy first is a great advantage and to develop this ability to its fullest requires hard work and constant practice. This factor has become increasingly critical as the speed and altitude of aerial warfare have increased. Many potentially good fighter pilots have been unsuccessful simply because they cannot learn to search the sky effectively."

pilots' visual acuity.[176] Evans told of "the eye strain" the pilots developed "trying to see 100 miles in all directions at once.... A tiring exercise as it must be continuous; you can't afford to relax." The normal ritual he performed entering MiG Alley included "unlocking my shoulder harness, loosening my safety belt, squirming my rear end around in the seat, shifting my back pack and beginning the endless swivel of my head and neck."[177] Many pilots, including ace Harold Fischer, took to carrying binoculars in the cockpit hoping to aid their visual search, but Salter and a few others thought the practice laughable, "like Nelson holding a telescope up to his blind eye."[178] Other pilots relied on other tools to improve their perceptive prowess, like one pilot's "special pair of half-mirrored distance glasses."[179] With the MiGs so difficult to see, and with the crop of older, veteran pilots leading most of the Sabre formations, many of the younger wingman joked that they were brought along just so they could help their leader find the enemy.[180]

If a formation of MiGs was detected, the flight leader was supposed to calmly alert the other Sabres to its presence. An informative radio call would allow the other nearby Sabres to locate the fight quickly and speed toward it to provide assistance. Mahurin offered one example of a radio call from a sortie. "The call should have been: 'Eagle Red Leader, this is Eagle Red Four. I think I have something spotted at twelve o'clock high.'" However, what came across the radio was, "Hey, I think I see something," followed by, "One of them is on my tail! Get him off!," and "You'd better pull in tighter. He's shooting mighty near you." Mahurin, whose flying call sign was "Honest John," repeatedly inquired about the location of the rapidly escalating fight before finally shouting into his microphone, "Listen,

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[176] Evans, *Sabre Jets Over Korea*, 202; *Resume of Our Tactics*, 14. Evans recalled that "planes sometimes seem to vanish or dissolve in the blinding blue depths of very high altitude." On medical efforts to study the effects of high altitude flight on the Sabre pilots' visual acuity, see *History of the 51st Fighter Interceptor Wing, Jul - Dec 1952*, 19.

[177] Evans, *Sabre Jets Over Korea*, 41, 94, 128.

[178] Thyng, "Operation of the 4th Fighter Wing in Korea," 6; Baker, "Report on F-86 Operations," 10; Hallion, "Air Dominance," 37; Sherwood, *Officers in Flight Suits*, 84; Salter, *Burning the Days*, 151.

[179] Sherwood, *Officers in Flight Suits*, 84; Werrell, *Sabres Over MIG Alley*, 185. When the optometrist warned Hagerstrom that wearing the special glasses might permanently damage his eyesight, the fighter pilot replied "I don't give a shit." Hagerstrom apparently bragged "that he could look at a 500-watt light bulb with these glasses and read the writing on the bulb."

[180] Hallion, "Air Dominance," 30. Brown remembered, "Some of our leaders were old guys in their thirties, and I was a young twenty-four-year old. So the difference in eyesight was significant." One exception was Baker, who Risner described as having "eyes like an eagle"—Baker became one of the top Korean aces. Risner, Oral History Interview, 12.

you bastards, this is Honest John. If you guys want help, tell me where the fight is and tell me now." Their response, "To hell with you, Colonel. Find your own damn Migs."[181]

Mahurin's radio exchange was atypical, not for its content but because an actual dialog occurred. The AN/ARC-3 VHF radio installed in the Sabre wasn't especially reliable and it had only eight channels that couldn't be retuned in the air. Of the eight channels, five were needed for operations around the air base, leaving only three available for communications over MiG Alley.[182] With dozens of F-86 pilots all clamoring on the radio, along with the radar controllers at Kimpo or Cho-Do, once a fight erupted pilots often couldn't get a word in edgewise. "Look out for those two!" was a commonly heard call that relayed no useful information but instantly sent everyone's pulse skyrocketing.[183] To encourage better radio discipline, the senior pilots in the 51st borrowed the advice of earlier World War II aviators and told their fellow pilots, "If that bogey ain't close enough to shoot – or get shot at – keep quiet."[184]

In the heat of battle, few followed the advice, which left others grumbling about the incessant "yak on the radio." Evans once recalled a "maddening moment" when he saw "a stream ... of MiGs" fly "beneath our formation. I ... was literally hopping with excitement trying to call out" the MiGs, "but the radio had erupted into such a babble I couldn't get in a word." On another sortie, the radio was "so boggled with fight chatter you couldn't maintain a sensible transmission or understandable reception." Evans complained, "I simply couldn't

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[181] Mahurin, *Honest John*, 82–83; *4th FIG Tactical Doctrine*, July 22, 1951, 26; *4th FIG Tactical Doctrine*, December 28, 1952, 20. The Fourth's tactics manual offered another example of a correct call, "Awning Red Leader, Awning White Two here, bandit's six o'clock high closing fast."

[182] Raebel, "Communications: Frequency Assignments." Two radio channels were used by the control tower, two were used to help vector the Sabres to landing, and one was used for emergencies. The radios couldn't be readily retuned on the ground either; maintenance crews had to requisition new crystals before a different frequency could be used. *History of the 51st Fighter Interceptor Wing, Apr 1952*, Chapter 2, Communications. Salter, with his elegant prose, described his experience with the radios: "The planes sit out in the weather and dampness affects them, the radios become unreliable. *Break!* they are crying in a fight and you hear nothing. The silence is uncanny. *Break right!* they are shouting, *break right!* For some reason you look back and there, behind you, is an intake the size of a locomotive." Salter, *Burning the Days*, 158–59. A "break" call indicated that an *immediate* defensive maneuver was required for survival.

[183] Evans, *Sabre Jets Over Korea*, 73; *FEAF Report on the Korean War*, II:10. On fighter sweep missions, three of four dozen F-86s would be launched on a single patrol, all listening and transmitting on a single radio channel. The chatter between the two pilots in *The Fighting 51st* was probably typical for its extraneous banter—"Uh, Rog, I'm goin' in now." "OK, you're clear. Go ahead." "Rog, I'm gonna fire now." "Uh, you're still clear" "OK, he's down. You got him too."—but atypical in that there was no one else trying to use the radio at the time. *Fighting 51st.*

[184] *Resume of Our Tactics*, 23.

coordinate or communicate with my wingman, and this really torqued my jaws." It also almost cost him his life, since Evans's wingman was unable to inform him that he was lost and that Evans was on his own.[185]

Most engagements in MiG Alley were short and frenetic affairs as both sides sought to exploit the element of surprise. Futrell noted that "often less than 3 seconds elapsed between first sighting [of the MiGs] through engagement to the break-off."[186] Many times, the MiGs would suddenly appear out of the blue. One pilot described combat as being "over like that. Snap! ... Somebody comes in and makes a pass and gets shot down."[187] Quick strikes weren't exclusive to the MiGs either. Blesse recalled his fifth kill "happen[ing] so fast it took me a moment or two to realize I had just gotten Number Five."[188] Cleveland's third kill also "wasn't much of a dogfight, just one diving turn and catching up to him."[189] The sudden start and finish of an aerial engagement was central to Salter's vivid description of battle:

> Suddenly a plane flashes by beneath: huge tail, red stars, incredibly close. I turn after it, glance quickly behind, my heart pounding. It's clear, but Kasler [Salter's wingman] cries, "Check your right! Look right!"
>
> Not two hundred feet away, plain, foreign-looking, is the wingman. I turn hard towards him and then partway back. He seems fixed, frozen there, like a hare in the headlights. I'm nearly behind him. It will be point-blank. Before I can fire there are four of them almost on top of us, coming in from the other side. "Break left!" Kasler is calling. They turn with us, like cars on a speedway, and we are going down, I can't see if they are firing. Then we are alone; they've broken off when we didn't see it. It's over. Above us the contrails are already fading.[190]

Other times, the Sabres were able to detect the MiGs as they streaked across the sky at high altitude, their massive formations drawing out "spider webs" with their wispy, white

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[185] Evans, *Sabre Jets Over Korea*, 42, 96, 184–86. Resembling Evans's experience, on a November 30, 1951, mission, Able 3 and 4 became separated. Able 4 thought he spotted his leader, and tried calling him on the radio, asking Able 3 to "wag his wings" to confirm it was him. However, Able 4's "radio plug had become disconnected, and when he established radio contact, he heard Able 3 calling for help." Able 3 had been attacking an enemy formation, thinking his wingman was with him "until he leveled and observed great balls of fire above his canopy." Howard et al., "FEAF Intel Form 1, 30 Nov 1951."

[186] Futrell, *USAF Operations in the Korean Conflict, 1 Nov 1950 - 30 Jun 1952*, 113.

[187] Evans, *Sabre Jets Over Korea*, 71–72; Hone, "Korea," 492.

[188] Blesse, *Check Six*, 71.

[189] Quoted in Trest, *Once a Fighter Pilot*, 91.

[190] Salter, *Burning the Days*, 156.

contrails. Upon observing the MiGs above, the American pilots would try to gingerly coax their aircraft up and into an offensive position, but they usually fell short due to the better altitude performance of the Soviet interceptor. The 4th's tactics manual stated: "If the MIGs are at a higher altitude than we—which is more often the case—we attempt to place ourselves in a position very close along side [*sic*] and below the enemy formation while moving in the same direction as they.... If, however, we are reasonably sure we have not been seen by the enemy, we often try to stay directly under him, or under and slightly behind him and wait for him to descend." In either case, the Sabres had "no choice but to keep [their] Mach high" and "wait until [the MiGs] made the first move."[191]

When the MiGs finally pounced, they would slice down into the Americans' formations with guns blazing before they streaked northward toward their Manchurian sanctuary. Evans once likened the MiGs "diving into us" to "bombs trying to catch somebody napping." Occasionally the aerial contests would devolve into swirling dervishes with repeated high-speed passes and fleeting, slashing guns attacks. Sabre pilots did their best to maneuver into the good tracking position that the A-1C(M) demanded during these "Korean merry-go-rounds," but achieving the stabilized position was a rarity as the MiGs rolled, dived, and zoomed trying to get away.[192]

Always outnumbered, the Americans had to be constantly alert to new MiGs seeking a quick kill. Many times, just as a leader was moving into an offensive position against one MiG, his wingman would call "Break!" on the radio and the flight lead would have to immediately shift his focus from glorious victory to mere survival. That usually entailed a "steep, high Mach, high 'G' descending spiral," an exhausting and physically demanding maneuver designed to lose the MiG. After one engagement spent straining against his "high pressure" G-suit, which "had damn near cut me in half," Evans wrote, "I felt internally as though I had been ruptured.... To hell with that high-G *spiral down* stuff, the Gs practically

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[191] Evans, *Sabre Jets Over Korea*, 125; Futrell, *USAF Operations in the Korean Conflict, 1 Nov 1950 - 30 Jun 1952*, 117; *FEAF Report on the Korean War*, II:7–8; Mahurin, *Honest John*, 37; *Resume of Our Tactics*, 15; *4th FIG Tactical Doctrine*, December 28, 1952, 10; Hise, "F-86E versus MiG-15 in Korea," 17. Mahurin identified the "three advantages" regularly enjoyed by the "Communists": "superior speed, superior altitude and advantageous position."

[192] Evans, *Sabre Jets Over Korea*, 89, 107; Hinton, "MiG-15 Versus F-86A," 12; *4th FIG Tactical Doctrine*, December 28, 1952, 10.

paralyze your ability to maneuver and you waste all your altitude options too quickly. I'll fight to stay upstairs where I'll have room to yank and roll, thank you."[193]

The American pilots also had to watch out for other Sabres jumping into their fight, ostensibly to assist, but often seeking to claim a MiG for themselves. Fischer remembered chasing down a flight of MiGs while another flight of nearby Sabres was intent on the same: "As we jockeyed for position, we almost collided with the other Sabres, since neither formation wanted to give way and lose the advantage."[194] At least Fischer and the accompanying Sabres didn't mistakenly open fire on each other. With fighters swirling around, and with the MiG and Sabre both similarly defined by their cigar-shaped fuselage and swept wing, it was sometimes difficult for pilots on both sides to distinguish friendly from enemy aircraft. On one occasion, Mahurin and his wingman became separated after they turned in opposite directions; Mahurin said "Break right and up," but his wingman heard "Break left." After turning 270 degrees, the two Sabres were "face-to-face," and Mahurin, "taking no chance at all" that the aircraft in front of him might be a MiG, "started firing immediately" before his wingman screamed over the radio, "Watch it, it's me."[195]

Knowing that they had at most only a few seconds available to line up behind a MiG and score a victory, and not having received extensive training in high-deflection "snap" shooting, Sabre pilots made the best of their limited chances, "tak[ing] on formations of Migs of any number."[196] While the 51st extolled its pilots to "Shoot to Kill!", with only little time to aim when facing an adept, maneuvering foe, sometimes the F-86 pilot resorted to just spraying some bullets out in front hoping for a lucky shot. But, like in air combat before,

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[193] Futrell, *USAF Operations in the Korean Conflict, 1 Nov 1950 - 30 Jun 1952*, 113; Hinton, "MiG-15 Versus F-86A," 10, 17–18; Evans, *Sabre Jets Over Korea*, 116–17; McMillin, "FEAF Intel Form 1, 17 Jun 1951"; Kenyon and Beckwith, "FEAF Intel Form 1, 9 Sep 1951"; Blesse, *Check Six*, 65. A "break" call indicated that an *immediate* defensive maneuver was required for survival. It's unclear if Evans's alternate defensive strategy was ever employed, but it is likely he was just venting in his journal.

[194] Fischer is quoted in Hallion, "Air Dominance," 38; Risner, Oral History Interview, 22. Risner told of trying to chase down a MiG when "an F-86 went right across my head. [The other pilot] said, 'I have this MiG.' So I said, 'You get out from behind that MiG, or I'll shoot you down.'"

[195] Mahurin, *Honest John*, 73–74. Only at close-range did the MiG's trademark high T-tail and mid-mounted wing become distinct. The "jet stream" tactic also exacerbated the identification problem because, unlike mass formations that all arrived together, new F-86s were constantly flowing into the area. See *4th FIG Tactical Doctrine*, December 28, 1952, 8. Most famously, Jabara accidently shot down his wingman, Richard Frailey, in the commotion of one battle. Werrell, *Sabres Over MIG Alley*, 121–24.

[196] Thyng, "Operation of the 4th Fighter Wing in Korea," 8; *4th FIG Tactical Doctrine*, July 22, 1951, 3.

the best results were obtained when pilots could sneak up close behind their targets and wail away from between 1,500 to 500 feet back.[197]

Even from those close ranges, hits were not always guaranteed.[198] And even if hits were observed, the Sabre's six .50-caliber M3 Browning machine guns, essentially a faster-firing version of the .50-cal machine gun from World War II, were not always capable of crippling the MiG target.[199] Salter described the Sabre's machine guns as "almost feminine in comparison" to the MiG's "cannon—the maw of a MiG seemed swollen and menacing."[200] Exacerbating the plight of the Sabres, the MiG-15's stern quadrant proved particularly resilient to the Americans' smallish and low-velocity .50-caliber shells. Some estimates suggested that up to 95 percent of bullet strikes against the MiG's rear would be ineffective at catastrophically disabling the aircraft.[201] On one occasion, a disheartened F-86 pilot reported getting "good 'strikes' along the right wing and fuselage" of his MiG-15 target, only to then watch the presumably damaged Soviet plane initiate "a 60 degree climb" to "at least 6,000 feet above the point where the F-86 had to level off to keep from stalling" and then fly to safety "across the Yalu River."[202]

Frustrated by a political border that they couldn't cross, flying aircraft that couldn't climb to reach their foe, and using bullets that couldn't bring their enemy down, but still enchanted with the allure of acehood and aerial victories, many Sabre pilots began taking matters into their hands. When one of their external fuel tanks refused to jettison at the start of an engagement, both Blesse and Jabara decided to defy higher guidance mandating that they return to base and chose instead to battle with the MiGs; their decisions nearly cost

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[197] *Resume of Our Tactics*, 16; Blesse, "No Guts, No Glory," 72–73.

[198] Howard et al., "FEAF Intel Form 1, 16 Oct 1951 (0401)." On one mission, Baker Lead closed to within "50 feet" of his MiG target firing "long bursts," but "no strikes" were observed.

[199] Cary to Commanding Generals, "Status of Development of New Weapons." Futrell, *USAF Operations in the Korean Conflict, 1 Jul 1952 - 27 Jul 1953*, 52.

[200] Salter, *Burning the Days*, 146.

[201] Futrell, *USAF Operations in the Korean Conflict, 1 Jul 1952 - 27 Jul 1953*, 46, 63. A MiG pilot defector explained that "Red pilots knew that to break would expose their cockpits to [the Sabres' gun]fire, whereas, by absorbing the [gun] fire in the engine and armor plate behind them, the MiG pilots found that they had an excellent chance to recover, or at least safely to bail out after the F-86's had broken off."

[202] *FEAF Report on the Korean War*, II:6. See other descriptions in Futrell, *USAF Operations in the Korean Conflict, 1 Nov 1950 - 30 Jun 1952*, 118. For example, one "experienced Sabre pilot fired 1,200 rounds at a MiG-15 at estimated ranges as low as 150 to 200 feet, and, although the MiG smoked, it still was able to cross the border under control."

them their lives.[203] Evans and Mahurin likewise recalled their fellow pilots getting so MiG-hungry that they began "taking extremely hazardous risks" like "purposely forget[ting] to call 'Bingo,'" the code-word for low fuel, in the hopes that a few extra minutes might bring along an easy MiG target.[204] Blesse actually ran out of fuel shortly after getting his tenth kill and nearly fell into North Korean hands, ejecting just a half-mile off the enemy coast.[205] The leading Sabre scorer at the time, Major George Davis, elected on one mission to abandon his squadron, taking his wingman to go hunt for MiGs alone—Davis was shot down and killed that afternoon.[206]

Perhaps the most grievous example of pilots' reckless pursuit of glory occurred when Sabre pilots started going north of the Yalu River searching for MiGs. Cleveland recalled the first time he became aware that pilots were routinely violating the Manchurian sanctuary. He was standing outside waiting for a bus in the pouring rain when a car stopped, the window rolled down, and the occupants shouted, "Get in, Lieutenant." Inside, Thyng and Mahurin, the 4th's Wing and Group commanders respectively, were bantering about their recent missions, when Thyng proudly announced, "You know my latest one was just after he took off. When you get 'em just after take-off and they're all full of fuel, they burn." Hearing the two colonel-leaders, fighter aces, and "role models" describe their trips north was sufficient justification for Cleveland and he noted that it soon "found its way into my psyche that's where the action was. I remember Colonel Mahurin saying, 'Well, wherever you get them, north of the river, over the river, south of the river, every time you shoot one down, that's one less that's going to be up the next day hunting you and your buddies.'"[207]

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[203] Blesse, *Check Six*, 65–67; Dille, "Jets' First Ace," 136, 139; Werrell, *Sabres Over MIG Alley*, 153–54. Later, Blesse would tell pilots without equivocation, "If you have a 'hung' external tank, leave the combat area." Blesse, "No Guts, No Glory," 55.

[204] Evans, *Sabre Jets Over Korea*, 98; Mahurin, *Honest John*, 54–56.

[205] Blesse, *Check Six*, 74–75. Blesse noted that before deciding to engage the tenth MiG, he knew he was already perilously low on fuel. His attitude was, "Hell, it's a tossup anyway. Why not?" However, gliding back toward Kimpo, the thought of becoming a POW entered his mind: "I had no relish for that, especially after Pyongyang Sally had broadcast the night of my eighth kill, 'Just wait, Major Blesse, we're going to get you and when we do, we're going to hang you from the Han River Bridge.'"

[206] Evans, *Sabre Jets Over Korea*, 210; Werrell, *Sabres Over MIG Alley*, 156–57; Bruning, *Crimson Sky*, 181–88; Blesse, *Check Six*, 55–56. Some pilots reportedly observed that Davis had "become more brazen, more aggressive, and more willing to take risks in Korea than he was during World War II.... George just didn't respect the MiG pilots." Others suggested that Davis "considered himself immortal" and had begun to exhibit "*MiG madness.*"

[207] Trest, *Once a Fighter Pilot*, 72; Cleveland, Oral History Interview, 40–42.

Mahurin had actually started streaking past the Yalu chasing MiGs months earlier when he was flying with Gabreski in the 51st. The two colonels came out of a meeting one day with the Fifth Air Force commander and concluded that the Communist sanctuary, which allowed the MiGs to "lurk on [their] side of the border, dart over to our side, shoot at an F-86 and return ... at will, ... was a distinctly unfair advantage and it was costing lives." Even if it was strictly against the rules, they both agreed that it was time the American F-86s finally caught "a break." Besides, they reasoned, better to be alive seated at a court-martial than to be shot dead in the skies over North Korea.[208]

The 51st's first mission north of the border was a resounding success. The "Maple Special" flight claimed three MiGs, the enemy pilots surprised no doubt by the Sabres' presence in Manchuria. Other Sabre pilots quickly learned of the action and soon whole squadrons assigned to the 51st were hunting for MiGs on the wrong side of the Yalu. When Mahurin transferred out of the 51st to become the 4th's Group commander, the pilots in that unit quickly followed suit. Although he continued to justify the flights on the basis of "forc[ing] the Communists to come to terms more rapidly," Mahurin also proudly observed that "with the border restrictions off, our pilots began to gain in victories over the 51st."[209]

For the Sabre pilots, killing MiGs north of the Yalu might have eventually helped thin the ranks of Red fighters appearing over MiG Alley, and it could have also generated a significant psychological advantage over the Communist pilots for the Americans, but it would do little to further their individual quests for glory unless they could figure out a way to claim the victory. The American pilots couldn't very well report the facts of an engagement conducted in clear violation of higher-guidance, and they certainly wouldn't forsake credit for the kill. Consequently, they concocted a standard cover story that went like this: "We had followed the enemy aircraft as they climbed for altitude, but kept well south of

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[208] Mahurin, *Honest John*, 68–69.

[209] Ibid., 69–71, 78, 80, 83–85. Mahurin offered another rationale for their flights north: "A nation should not handicap its fighting men so that their chances of survival in battle against the enemy are reduced substantially." Mahurin was in "an intense competition with Gabby" Gabreski, his former commander in the 51st, remarking, "I would have given my eye teeth to shoot down all the Migs in China—especially if it contributed to bringing the war to a close. At the same time I would almost have given my right arm to beat Gabby in every way possible."

There was one restriction that most pilots adhered to, though: they would not strafe any MiGs on the ground—that would be too obvious a violation of Manchurian sanctuary. Instead the Sabres orbited over the Communist airfields waiting to see dust clouds kicking up behind the MiGs as they started down the runway. Then the Sabres would swoop down and try to catch the MiGs just as they left the ground. See, for example, Blesse, *Check Six*, 67–69.

the border. When they came down into our territory we attacked, shooting down three while the rest escaped us by flying north. The three we destroyed fell to the ground on the Manchurian side of the border." Mahurin proudly noted that the ruse "satisfied our intelligence man," but that was only the first step in getting credit for the victory.[210]

Getting Credit

Initially in the Korean War, there were three conditions that could result in credit for an aerial victory: 1) if an enemy aircraft was observed to "strike the earth" by another pilot or someone on the ground; 2) if "gun camera film showed" or another pilot "witnessed aircraft disintegration, shedding of a major component necessary to sustain flight, a persistent fire in the engine or tail section, or pilot bail-out"; or 3) if the enemy aircraft was seen by another pilot "in such a position that known limitations or circumstances would preclude possible recovery." Only infrequently was a credit shared. If two pilots could prove that they both contributed to the kill, then the Air Force would recognize both, but only with a ½ credit apiece.[211] In the turbulent skies over Korea, with pilots flying only a set number of missions before rotating back to the States, and with the war frequently on the verge of ending at the negotiating table, gathering only half-kills rendered the chances of a pilot accumulating the sought-after *five* that much more remote.[212] Luckily for the flight leads,

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[210] Mahurin, *Honest John*, 70, 84; Cleveland, Oral History Interview, 41; Werrell, *Sabres Over MIG Alley*, 132. Mahurin's statements cast doubt on the veracity of intelligence summaries like that published for October 25, 1952, which read: "The leader of the first Sabrejet element closed to 2,000 feet on his target, scored hits on the left wing, and the Red aircraft immediately decelerated. Two more bursts resulted in many more hits on the MiG, and the Red pilot bailed out 12 miles southeast of Sinuiji. *The pilotless plane continued on a west heading, finally crashing on the Manchurian side of the Yalu River, approximately two miles north of the Antung Airfield*" (emphasis added). "Enemy Activity in Korea: Air to Air," October 25, 1952, 11–3–4. The gig was finally up in late January 1953. Questioned on his northern sortie by Colonel David Jones, Captain Dolph Overton elected to tell the truth and the next day the Air Force's newest ace was grounded, stripped of his medals, and ordered home. He didn't receive credit for his five victories for almost a year. The majority of border violations ceased after Overton was sent home. However, some like ace Lonnie Moore kept flying north under the impression that the Fifth Air Force commander "says screw the Yalu." In June 1953 Moore was caught flying in Manchuria and was also promptly shipped home. See Werrell, *Sabres Over MIG Alley*, 135–36.

[211] Futrell, *USAF Operations in the Korean Conflict, 1 Nov 1950 - 30 Jun 1952*, 126; Werrell, *Sabres Over MIG Alley*, 137; Haulman, "Introduction: Korean War Aerial Victory Credits"; Maurer, *USAF Credits: Korean War*. The ½-credit policy mimicked that of World War II. In contrast, during World War I, pilots and observers could both be awarded a full credit for a single downed enemy aircraft. For a brief period, Fifth Air Force also promised to award credit for an "aircraft [that] was observed to explode or burn while *on the ground*," but that criteria was quickly rescinded (emphasis added).

[212] Mahurin, *Honest John*, 23; Evans, *Sabre Jets Over Korea*, 141. Mahurin and Evans both worried that the war would end before they had a chance to prove themselves. The armistice would not be signed until July 27, 1953.

the formation practices ensured that they would usually earn full credit for any downed aircraft. Together, the policy and the practice ensured that the glory of air combat remained tightly focused on the individual heroic pilot.[213]

Cleveland had relied on newly released Russian documents to verify his victory claim and earn credit for his all-important fifth kill fifty-five years later. While some Sabre pilots benefited from intelligence reports corroborating their claims, most used more traditional sources to validate their aerial triumphs.[214] One was the small AN-N6 gun camera mounted in the Sabre's air intake. While the camera could occasionally capture some spectacular imagery (figure 3.20), most of the time the World War II-era camera proved ill-suited for jet-age air combat. The high-speed, slashing attacks that characterized most Korean dogfights made it difficult for the camera's fixed twelve-degree by seventeen-degree field of view to capture damage to a MiG target that appeared on only a few frames of film.[215] Additionally, on occasions when a close-range, stern attack was made, the Sabre pilot's attempt to film his

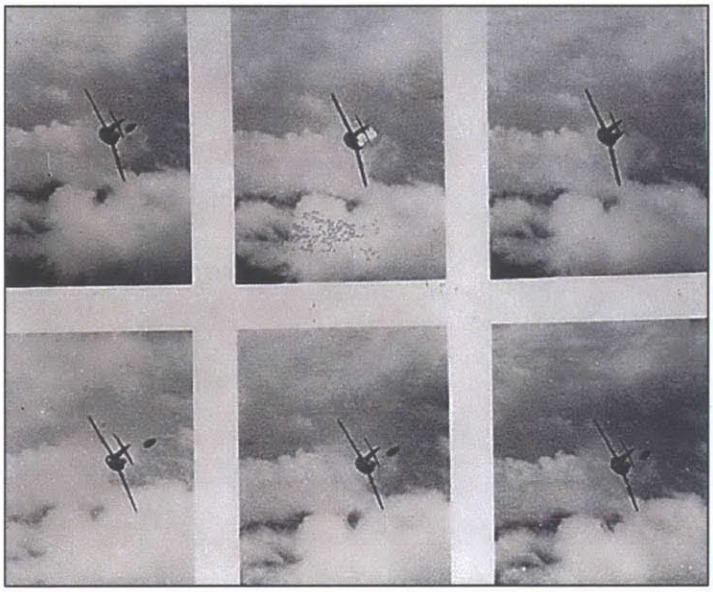

Figure 3.20. Ejection of a MiG-15 Pilot.
The gun camera in Air Force Captain Edwin "Buzz" Aldrin's F-86 Sabre captured these images of a MiG-15 pilot ejecting while under attack. The sequence runs right-to-left, top-to-bottom. (Source: NARA)

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[213] Occasionally a pilot in a news story would credit his wingman. See, for example, "Jet Flier Shy of 'Ace' by 1 in 5 Fights." Cleveland also acknowledged the contributions of the ground personnel in Trest, *Once a Fighter Pilot*, 83. The importance of the ground crew personnel to the mission was also emphasized in *Fighting 51st.*

[214] Werrell, *Sabres Over MIG Alley*, 178. The unit intelligence officer corroborated Cecil Foster's claim for his fifth kill four days after the sortie, based "probably from radio intercepts."

[215] "Standard Aircraft Characteristics: F-86E," 3; Strauss, *Analysis of Korean Air-to-Air Combat Film*, 4; "Enemy Activity in Korea: Air to Air," November 15, 1952; Hollstein to Banfill, "Comments of Study," 2; "Gun-Camera Records Kills"; "You've Got to Prove It!"; Beckwith to Commanding General, 5th Air Force, "Wing Fuel-Load in MiG-15"; Blesse, *Check Six*, 64–65. The FEAF report noted that "the most convincing and fool proof means of confirming a kill is by the gun camera carried in each Sabrejet." Evaluating the gun camera installation on the F-80 and F-84E, Hollstein noted, "It is obvious that the role of combat recording photography has been neglected since the termination of hostilities in World War II." Even by 1955, the *Fighter Weapons Newsletter* was still complaining about the N-6 gun camera, calling it "a bundle of trouble." When it worked, the gun camera footage could also be used as a source of intelligence on the MiG; for example,

kill was frequently thwarted by the diminutive striking power of his aircraft's .50-caliber ammunition: hits might be observed, but the film evidence would invariably fail to reveal significant damage. For example, Fischer once fired "several long bursts" into a MiG from close-range, but the enemy aircraft kept flying. As Fischer was maneuvering back for another attack, the MiG pilot ejected and the enemy plane went into a steep dive toward the ground. Knowing "that there was no positive verification [of the kill] on the gun camera film," Fischer followed the empty plane down and "strafed the wreckage for confirmation purposes."[216]

Other times, the camera and film simply failed to work. Despite the base photo lab at Kimpo processing some 23,000 feet of combat film a month, pilots were routinely frustrated. Their film wouldn't run, it would run out at an inopportune time, or it would be too blurry or otherwise distorted to reveal the necessary images.[217] One 1952 Air Force inspection of the operations in Korea declared "gun camera performance is still not satisfactory." Some Sabre pilots estimated after the war that their cameras only worked between 10 and 20 percent of the time.[218] Evans recalled his squadron-mates complaining that they were "flying a quarter-million-dollar airplane with a two-bit sight and camera." The camera had already cost Evans one kill, and after landing from another exciting mission, Evans fumed, "my film didn't come out again. It makes a man feel like a jackass to have no film to show after a good scrap."[219] Of course, there was always the chance that the camera

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combat film analysis seemed to indicate that the MiG carried fuel in its wings, contradicting earlier assessments that all its fuel was carried solely in the fuselage.

[216] Hallion, "Air Dominance," 36; Hinton and Wingo, "Analysis of Operations at Kimpo," 30. Hinton reported similar occurrences: "In other cases, pilot reports and film verification showed a large number of strikes on the MiG-15, with the latter continuing his flight with little or no reduction in speed. As a result, it was always necessary to follow the MiG to the ground, often at speeds in excess of the normal Mach, to insure his destruction."

[217] *History of the 4th Air Base Group*, May 1952, 6; *History of the 4th Air Base Group, Jun 1952*, 6; Alkire, "Gun Camera Brief"; Porter to Director of Reconnaissance, "Report of Staff Visit"; *History of the 51st Fighter Interceptor Wing, Mar 1952*, 13; Hise, "F-86E versus MiG-15 in Korea," 20–21. There were also issues developing the film in an austere combat environment. Initially, there was "only one film developer available in the combat theater and [it was] 250 miles away from [Kimpo]." When the bases built their own on-site film facilities, they frequently encountered problems obtaining reliable electricity and sufficient quantities of clean water. See Meyer to Commanding General, Air Defense Force, "F-86 Activities Report," 3; *History of the 4th Fighter-Interceptor Wing, Jul - Dec 1952*, 163–67.

[218] Werrell, *Sabres Over MIG Alley*, 277n74; Porter to Director of Reconnaissance, "Report of Staff Visit"; *History of the 334th Fighter Interceptor Squadron, Oct 1951*, 4.

[219] Evans, *Sabre Jets Over Korea*, 86, 113, 134. Evans was ecstatic when his gunnery film "came out good for a change." Naturally, only the best gun camera footage found its way into *Fighting 51st* Reel 3.

did work, and when the Sabres started flying north of the Yalu, the pilots had to take great care in ensuring that their violations were not documented on film. Mahurin recalled, "We had to kill a lot of combat-film footage."[220]

Fortunately, whether the camera worked or not, there was usually a wingman, properly indoctrinated on the importance of deferring to his flight leader, ready and eager to validate the claim. Snuggled close to the lead aircraft, the wingman was usually in prime position to witness and verify the aftermath of his leader's attack. In addition to visually searching around their flight leader and protecting his six o'clock, validating his claims, the wingmen quickly realized, was one of their key responsibilities. For example, Cleveland recalled one post-mission discussion that ended with his junior wingman responding, "Yeah, I saw what you saw and whatever you claim."[221] Moreover, a distracted or momentarily absent wingman sometimes resulted in the loss of a confirmed kill, which was another reason why flight leads were continually harping on their junior wingman to pay attention and maintain formation.[222] Ace George Davis often made a point of alerting his wingman to an impending kill by calling out "Look now, Baker Two" just before flaming a MiG; sadly, those were also his last words.[223]

There were occasional conflicts between a wingman and flight leader over a victory credit. Mahurin remembered one clash between Thyng and his wingman, Paddy Harbison. Thyng, already a World War II ace, chased down two MiGs and quickly downed them both, marking his fourth and fifth kills and earning him ace status for the Korean War. "[Paddy]

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[220] Mahurin, *Honest John*, 72, 83–84. Mahurin recalled his pilots "coming back from missions with some of the damndest pictures. Migs with wheels, flaps and dive breaks extended in preparation for landings; Migs just breaking ground after take-off; Migs upside down, sideways, in formation, out of formation and so-on—with most of the picture taken just around the enemy-held air bases." All "that film had to be screened."

[221] Trest, *Once a Fighter Pilot*, 81; Werrell, *Sabres Over MIG Alley*, 132. Cleveland ended up claiming a probable on his July 11, 1952, mission. Werrell described another typical encounter: DeArmond remembered his flight lead, the Wing commander Thyng, asking him before they stepped into the debrief where he had seen Thyng's MiG go down. Knowing that they had been deep inside Manchuria before engaging the MiG, DeArmond responded, "somewhere around the mouth of the Yalu," to which Thyng replied, "Son, you have a bright future in the Air Force."

[222] Sherwood, *Officers in Flight Suits*, 88. Sherwood described one engagement that illustrated the importance of having a wingman to verify a claim: under attack, an American flight lead somehow managed to whip his jet around and shoot-down the attacking MiG moments before ejecting from his own damaged Sabre, but because his wingman had panicked and already left the fight, the MiG claim was denied. Years later, still frustrated by the experience, Turner remarked: "As far as the Air Force is concerned I never got a MiG, but as far as I'm concerned, I got three." Hagerstrom demonstrated that there was another way to verify a MiG kill without a wingman or gun camera film when he returned with a piece of a MiG aircraft stuck in his aircraft.

[223] Evans, *Sabre Jets Over Korea*, 210.

was really bitter about Harry's being so greedy," Mahurin remembered. "Paddy claimed that Harry should have shot the first MiG down and turned the other one over to him, sharing the wealth, so to speak. Harry couldn't see it, because those two victories made him a jet ace."[224] Flying on Jabara's wing, Giordano recalled one occasion when he returned to base ecstatic with having earned a kill, only to have Jabara sharply rebuke him and instead claim the kill on the grounds that he as the flight lead had initiated the attack.[225]

As the Sabre pilots traipsed north of the Korean border and padded their victory totals with MiGs they caught during take-off or landing, and with some leaders pressuring their wingman to validate otherwise questionable claims, the Korean War pilots experienced a revelation shared by their predecessors in the First World War: despite the popular narrative, the glory associated with individual aerial victories was not without blemish. Mahurin remarked that his boys, "considered it slightly dirty pool to shoot [the MiGs] down just as they were trying to land." Likewise, Salter compared he and his fellow Sabre pilots to "overcoated gangsters in limousines, high above North Korea … we too were sleek for murder."[226] Still, the pilots continued, knowing that "each victory added up" both for the war effort and for them as individuals.[227] Moreover, the swashbuckling "bravado" with which the American pilots went about their tasks was, in Mahurin's estimation, a "veneer to cover up the fact that they were well aware of the dangers of combat flying."[228] One pilot quipped, "It sounds great to be a fighter pilot, but when you see those 30-millimeter cannon balls coming at you (and it only takes one to blow the tail of an airplane off), then people say wait a minute, this is a little too sporty for me, and then they back off."[229]

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[224] Mahurin, *Honest John*, 87–88. The dispute was obviously not featured in the ensuing news report: "New England Flier Becomes 16th Jet Ace." See also Werrell, *Sabres Over MIG Alley*, 190.

[225] Werrell, *Sabres Over MIG Alley*, 153–55; Jabara, "We Fly MiG Alley," 27; Hallion, "Air Dominance," 53–54. Giordano noted that in the ensuing discussion, Jabara "being the Major and Executive Officer and me being a punk second lieutenant, I lost the argument." Jabara was more modest and complementary toward his wingman in his *Air Force* article: "[Being a wingman] is a tough assignment and as far as I'm concerned half my victories should go to good wingmen…. To me he's worth his weight in .50 caliber ammo."

[226] Salter, *Burning the Days*, 141, 153. Salter noted, "It was victory we longed for and imagined. You could not steal or be given it. No man on earth was rich enough to buy it and it was worth nothing. In the end it was worth nothing at all."

[227] Mahurin, *Honest John*, 84. Cleveland similarly shrugged off any concerns, blandly observing, "Every kill counts." Trest, *Once a Fighter Pilot*, 72.

[228] Mahurin, *Honest John*, 30–31.

[229] Quoted in Sherwood, *Officers in Flight Suits*, 87.

On the surface, many pilots continued to popularize the "clean, impersonal" imagery of aerial combat, with victory signaled from a distance by a gracefully descending white parachute, the occupant no doubt shaking his first and cursing at the victor.[230] However, the relatively close-quarters fighting and the overarching desire to confirm any kills produced haunting sounds and imagery during the aerial contests. Mahurin recalled seeing his wingman get hit by a lucky MiG cannon shell, then hearing frantic, "labored breathing" over the radio and calls, "Am I on fire? I've been hit personally.... Tell me, am I on fire? Am I on fire?" The wingman ejected and Mahurin "never saw him again."[231] Another American remembered seeing a stricken F-86 pilot "squatting in his seat trying to shove the canopy off the F-86 when his airplane went straight into the ground."[232] Fischer had the misfortune of witnessing one of the more disturbing images of the air war as he passed a flaming MiG and saw the "pilot beating on the canopy, trying to escape. The heat must have been intolerable for the canopy was changing color and the smoke was intense." The sight had a powerful effect on Fischer: "Up to that moment the enemy had been impersonal, each aircraft a target that had little meaning and not associated with flesh and blood. But the sight of another man trapped in the cockpit of a burning aircraft with no power and no place to land was impossible for me to forget."[233]

As in the past, the sordid "richness" of air combat was rarely acknowledged. Instead, the public and the pilots were treated to stories and images that celebrated the glory of air combat and its gallant aces, warfare conducted at a comfortable distance from the enemy over beautiful landscapes and against a vibrant blue sky (figure 3.21). But, as before, the pilots knew that air combat remained a brutal and gruesome business of killing. Korean War aviators, like their predecessors, sought victory wherever they could find it and however they

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[230] Mahurin, Honest John, 86–87, 125; Sherwood, Officers in Flight Suits, 90. Sherwood quoted Risner's assessment that air combat is "not dirty, like down in the trenches.... When people die, you don't see it.... You're not aware of the blood and pain." Others like Mahurin distanced themselves from the combat, rationalizing that they were shooting down airplane "objects, not people."

[231] Mahurin, *Honest John*, 50–52. After the war, Mahurin learned that his wingman survived the ejection, emerging from "prison camp at the end of the war, alive and well."

[232] Hallion, "Air Dominance," 34. DeArmond described the poignant sight. See also Werrell, *Sabres Over MIG Alley*, 150; Mahurin, *Honest John*, 48, 127.

[233] Hallion, "Air Dominance," 37; Werrell, *Sabres Over MIG Alley*, 170. Fischer "thought the only humane thing to do was to put the [MiG] pilot out of his misery," even after the MiG pilot tried to ram Fischer with his disabled MiG, but when Fischer slid his Sabre "back onto his tail," the "intense heat from the burning MiG ... caused a misfire of a .50-cal machine gun round," which instantly "shut down the guns, severed a rudder cable, and subsequently dumped my cabin pressurization."

could win it. Blesse remarked that he "was surprised at how cold and calculating I had become" as he selected his prey and prosecuted his attack.[234] The 4th implored its pilots, "When in doubt, attack."[235] Mahurin remembered doing just that: "We shot them down in the landing pattern, we shot them down on local test hops, we shot them down on training flights, and we shot them down anywhere we could find them."[236]

Figure 3.21. Jabara becomes History's First Jet Ace.
Note the one hung external fuel tank.
(Source: USAF, Painting by Steve Doyle)

With the emphasis on claiming glory through aerial victory, one would imagine that the Sabre pilots would welcome their new gunsights, which promised to increase their chances at earning another all-important red star for their fuselage. Alas, most shunned the new technology.

Using the New Gunsights

When the newer Sabres with their A-1C(M) gunsight and its accompanying APG-30 radar started arriving in theater in mid-1951, the Sabre pilots had already started encountering the massive formations of MiGs circling high above. The maddening experience of helplessly watching scores of potential MiG kills overfly them was fresh on the minds of the fourteen F-86 aces that gathered before the CSAF for a late-summer 1952 meeting. There, the aces "vigorously" argued their case to General Vandenberg: the new A-1C(M) radar gunsight in the F-86E wasn't working. Moreover, the once-touted system was

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[234] Blesse, *Check Six*, 65.

[235] *4th FIG Tactical Doctrine*, July 22, 1951, 2. "Many times the tide of an air battle has been turned by apparently suicide attacks on superior numbers of enemy aircraft and injecting enough confusion and panic into the situation to cause the larger force to take the defensive and attempt to make its 'operations elsewhere.' This often results in major damage to the larger force inflicted by the numerically inferior but aggressively superior attacking force" (emphasis in original).

[236] Mahurin, *Honest John*, 84.

actually hindering the American pilots' struggle for aerial supremacy. They would be better off, they told the Chief, if they could rip out the new sights and replace them with the older, more reliable, and lighter-weight K-14 or Mk-18 gunsights.[237] Swayed by their arguments, Vandenberg on September 4, 1952, ordered the Air Proving Ground at Eglin AFB, Florida, to conduct an immediate, "accelerated comparison" of the new, radar-ranging sights to the older, manually ranged lead-computing gunsights. The outcome of the test would decide the immediate future of radar and advanced gunsights in Air Force fighters.[238]

Some histories attribute the controversy over the new radar-ranged gunsight to the older combat pilots' reluctance to adapt their practices to the new technology and their brazen, self-serving attempts to preserve their place at the top of the fighter pilot hierarchy. For example, Thomas Wildenberg claimed that "older, more veteran air aces" like Gabreski "had the most to lose" when the A-1C(M) arrived in theater: "As an elite fraternity within the Air Force, their status depended upon their skill in downing enemy aircraft—skills that took many missions and combat encounters with the enemy to perfect." With its promise of being "almost completely automatic in its operation," the new gunsight, according to Wildenberg, threatened to dilute this guild of aces with crops of younger pilots who possessed significantly "less combat experience."[239] When Lieutenant Low became the youngest ace, it was, according to Wildenberg, his success that riled the established aces, not his propensity to break formation. Furthermore, the success of youngsters like Low, according to the argument, demonstrated the simplicity and utility of the new sights if one was not hidebound by obsolescent practices.[240]

Even after almost fifty years, the Korean aviators' opinions of the new gunsights remained sharply polarized, with one group claiming they "were not bad in the F-86E" and others declaring that "the improved radar ranging system that came with the E model was not much better" than the earlier sights.[241] It is through this controversy that we most clearly see the competition between the "great machine" and "great pilot" narratives, both mitigated

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[237] *Accelerated Comparison Test*; *FEAF Report on the Korean War*, II:11; Werrell, *Sabres Over MIG Alley*, 30.

[238] *Accelerated Comparison Test*; Werrell, *Sabres Over MIG Alley*, 30–32; Wildenberg, "A-1C(M) Gunsight," 34–36. Curiously, the Air Proving Ground's report identified September 4, 1952, as the date of the CSAF's tasking, but FEAF's final *Report on the Korean War*, Werrell, and Wildenberg all fixed the date as September 8.

[239] *A-1 Series Sight*, 2; Wildenberg, "A-1C(M) Gunsight," 35–36.

[240] Dorr, Lake, and Thompson, *Korean War Aces*, 61; Wildenberg, "A-1C(M) Gunsight," 36.

[241] Quoted in Hallion, "Air Dominance," 51.

by the myth of the fighter pilot, and the consequent evolution of the human-machine system as pilots struggled to learn the intricacies of their new equipment while those technologies were also undergoing their own transformation based on the reality of Korean air combat.

Shooting (and Aiming) to Kill

As in wars past, the Korean War fighter pilots preferred to get as close as possible to their targets before opening fire. Jabara for one preferred to do his work from within 700 feet.[242] Blesse too had a tendency to get right behind his targets. On one occasion, he steered his formation so close to his target that when it began disintegrating from his bullets, "a big hunk of … stabilizer came off" and got "sucked into my wingman's airscoop"; the wingman ended up having to eject over the water. Another time, Blesse opened fire on an LA-9 from only 200 feet away; as the North Korean plane started coming apart, it sprayed aviation oil all over Blesse's Sabre, leaving his glass canopy looking "like someone had pulled a shade over it."[243]

The Sabre pilots knew that firing from close-range simplified the gunnery problem and substantially increased their chances of scoring a hit. It also helped compensate for the lackluster performance of the F-86A's Mk-18 gunsight. Designed for propeller-driven, World War II aircraft, the sight was not properly configured to deal with the high angular rates and excessive G-forces that characterized air combat in the jet age. One combat report on the Sabre's Mk-18 complained that the gunsight's "ranging control [was] much too stiff and erratic" for the rapid closure rates in modern dogfights, which made it nearly impossible for the pilot to properly span the enemy target. Pilots also complained of the "excessive movement of the sight pipper" during tracking and "excessive movement of the reticle when [the] guns were fired." Furthermore, the Mk-18 was optimized in the Sabre for use at an airspeed of 357 knots, but the Sabre routinely traveled more than 100 knots faster than that. In the end, many Sabre pilots deemed the Mk-18 "worthless." Rather than rely on the sight's lead-computing functionality, pilots simply used the gunsight in its fixed, iron-sight mode.[244]

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[242] *Accelerated Comparison Test*, Inclosure 1:6.

[243] Blesse, *Check Six*, 64, 72. Blesse was able to clear his windscreen by accelerating above 350 knots.

[244] *Accelerated Comparison Test*; *FEAF Report on the Korean War*, II:11; Werrell, *Sabres Over MIG Alley*, 30; Hinton and Wingo, "Analysis of Operations at Kimpo," 31; Peterson, "F-86A Operation as a Fighter-Interceptor," 2; Broad, "FEAF Intel Form 1, 21 Dec 1950"; "Enemy Air Activity, 30 Dec 1950"; Meyer to Commanding General, Air Defense Force, "F-86 Activities Report (Special)," 7. On the effects of airspeed on boresighting aircraft guns, see "Harmonization and Firing Techniques," chap. 4.

Without the benefit of the LCG, the Sabre pilots were not much different than the pilots from the First World War, endeavoring to get so close to their targets that their bullets essentially couldn't miss. But, sneaking up behind a target to destroy it at close-range remained difficult in practice, especially with the MiGs' preference for quick, slashing attacks initiated from high altitude. Additionally, if a Sabre pilot did find a suitable MiG target, his enthusiasm for the looming kill and his worry that his MiG prey might suddenly become aware of the attack and maneuver to spoil the shot often led to less-than-ideal gunshots. For example, during his first air-to-air engagement in Korea, Blesse went chasing after a MiG proudly declaring over the radio, "Colonel, I'm going to get me a MiG." However, Blesse was far out of range when he opened fire and his target sped away unscathed.[245]

Consequently, while many strove for the perfect close-range, directly astern position, and while some pilots may have actually thought that they had achieved it, few ever did. One review of Korean War gun film concluded that most attacks took place "at ranges and angles off in excess of 1500 feet and 10°."[246] The report's findings echoed earlier assessments of air combat from World War II that identified a "wide-spread" problem of pilots "grossly" underestimating their "ranges and, to a lesser extent, angles-off" from their targets.[247] Harkening back to Mahurin's warning to his fellow World War II aviators not to believe the movie portrayals of air combat, officials in 1952 likewise concluded that the Korean War pilots' exposure to "films released for public consumption, showing close-in, highly effective attacks on enemy aircraft" was having a pernicious effect on their performance in actual air combat. So too was the pilots' exposure to non-realistic gunnery training.[248]

These were the exact issues Davis's team at Wright Field hoped to address when they set out working with MIT to develop the A-1C(M)—a gunsight that would help pilots take more effective, longer-range, higher-deflection gunshots with minimal training. But there was a hitch. As noted earlier, the accuracy of the gunsight's prediction angle was based on three assumptions, and in Korea those assumptions rarely held true. For example, rarely did the Sabres have the opportunity and the time to match the target's plane of motion, the

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[245] Blesse, *Check Six*, 57, 65. See also Evans's accounts of his first engagements. Evans, *Sabre Jets Over Korea*, 84–85, 116.

[246] *Accelerated Comparison Test*, 1. Emphasis in original.

[247] Ibid., Inclosure 2:4; Thorne, "Major James H. Thorne," 21.

[248] *Accelerated Comparison Test*, Inclosure 2:4; Mahurin, "Major Walker M. Mahurin."

critical step that allowed the A-1's gyroscopes to measure the rate of change and calculate the proper prediction angle. The 51st's tactics manual noted the irony, reminding pilots, "Proper tracking is mandatory for the [A-1C(M)] sight to compute properly"; then it declared, "Tracking is not possible in high 'G' maneuvers or acrobatic flight and reliance on the fixed sight, manual ranging procedure, and tracers becomes the general rule in these cases."[249] The A-1C(M) sight might have done well shooting down a large bomber aircraft under more docile, controlled conditions, but pilots were discovering that the gunsight was not especially well-designed to deal with the small, nimble, maneuvering MiG fighters over Korea.

There were other A-1 design limitations that became apparent in MiG Alley. For example, when the Sabre pilot pulled more than 3Gs, a second reticle image appeared above the primary—the result of the G-distorted optics on the windscreen. "Pilots have been known to fire using the false image," one Sabre pilot reported. Echoing others' concerns, the same pilot also complained that the range drum was too difficult to read and "required too much concentration" to interpret, and that the reticle image and pipper needed to be a different color, like "lime green," so they were easier to see when the target was in-line with the sun. Another pilot noted that the variable diameter reticle was insufficiently scaled, so that at long-ranges it did not properly span the target, "which sometimes [gives] pilots the impression that the sight is not ranging properly." As was common with the Mk-18, pilots frequently griped about the A-1's "nervous pipper" when they fired their guns.[250]

A major critique of the A-1's design was the pilot's inability to control the radar, which, when coupled with the radar's ability to lock targets far out of range of the guns, produced wildly erratic and distracting reticle movements at long-range. It was, the pilots said, "a first-class headache to the inexperienced pilot." Draper's team had actually anticipated this situation, which is why a pilot was instructed to depress the electrical caging switch on the throttle grip until he was ready to begin tracking the target. But everyone soon

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[249] *Resume of Our Tactics*, 16. The value of tracer ammunition, however, was controversial. See assessments in Futrell, *USAF Operations in the Korean Conflict, 1 Nov 1950 - 30 Jun 1952*, 119; Thyng, "Operation of the 4th Fighter Wing in Korea," 7; Blesse, "No Guts, No Glory," 72.

[250] Commanding General, 5th Air Force to Commanding General, Far East Air Forces, "Evaluation of the A1CM Gun Sight."

learned that it was impractical to constantly fly around holding the caging button down, so another solution was introduced in mid-1952.[251]

The Jenkins range limiter, so named after its designer, Jack Jenkins, allowed the pilot using a variable rheostat mounted in the cockpit to essentially adjust the "maximum operating range" of the sight. As Jenkins described it, the range limiter was "based on the concept that there is no fundamental reason for flying a perfect lead pursuit course [as determined by the gunsight] at ranges appreciably in excess of the effective range of the weapons carried. The use of a range limiter allows the pilot to sweat out the initial transients and get on an approximately correct lead pursuit course while avoiding some of the undesirable sight dynamics which are prevalent at long range." With the limiter installed, if the radar reported a range in excess of the selected maximum range, the prediction computer in the A-1 ignored the radar data and instead used the preselected range to compute the bullet's time of flight, thereby reducing the commanded prediction angle and the sight's sensitivity. Once the radar range collapsed to less than the preselected value, the actual radar range to the target was used and the correct prediction angle displayed. The Jenkins modified sight also provided a visual cue to the pilot when the radar-computed range to the target was less than the selected maximum range, obviating the need for the pilot to continually cross-check the radar range drum located on the side of the A-1C's sight unit. Despite being "a rather crude affair thrown together on a dark night," the Jenkins range limiter "proved popular immediately." With its introduction, the Sabre pilots at Kimpo noted, "the fire control system ... approached more closely the ultimate of complete automatic function."[252]

It wasn't just limitations with the sight that stymied Sabre pilots' attempts at scoring a kill, however. As noted earlier, their ammunition also left something to be desired. The ineffective striking power of the .50-caliber bullet meant that, even against a stable target, the longer-range, high-deflection aiming capabilities of the A-1C(M) could not be fully exploited. Many Sabre pilots began complaining about their armament almost immediately after they started tangling with the MiGs. One of the first combat intelligence reports detailing a MiG-15 battle noted that it took "an unusual amount of .50 caliber ammunition" to achieve

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[251] Ibid.; Jenkins, "Some Notes," 51.

[252] Jenkins, "Some Notes," 51; Futrell, *USAF Operations in the Korean Conflict, 1 Nov 1950 - 30 Jun 1952*, 119–20; *FEAF Report on the Korean War*, II:11; Wildenberg, "A-1C(M) Gunsight," 34–35; *History of the 51st Fighter Interceptor Wing, Jul - Dec 1952*; *History of the 4th Fighter-Interceptor Wing, Jul - Dec 1952*, 70; *History of the 6400th Air Depot Wing, Feb - Jun 1952*, I:230–31.

"lethal results."[253] A subsequent report noted that by December 1950, "the consensus [among Sabre pilots] is that fire power of the F-86 is not sufficiently destructive, and should be modified with a caliber heavy enough to insure structural damage with a minimum number of hits."[254] Subsequent analysis concluded that it took on average almost 8½ seconds of concentrated .50-caliber fire, equating to 1,024 rounds, to bring down a MiG, an extraordinarily long time for a "pilot concentrating on a gunnery problem" to be in a position "most vulnerable to enemy attack." Finally in early 1951, members of the 4th Wing submitted an "Unsatisfactory Report" on their M3s, recommending that the Sabre's six .50-caliber machine guns be replaced by four 20-mm cannons.[255]

The dissatisfaction with the M3 was not, however, universal. The question "Will four 20mm cannon do a better job than six .50 caliber machine guns?" became, according to one September 1951 report, "probably one of the most widely debated points among the combat crews of the F-86 in Korea." Gabreski considered the Sabre's "fire power ... adequate for fighter vs fighter operations." Thyng reported that "if you are within range and in position, the 50 caliber machine gun is more than adequate." Baker defined that range as 2,000 feet, while others claimed that the .50-caliber was only suitable out to ranges of 1,500 feet. The 4th's report on F-86E operations was more pessimistic, declaring that the maximum effective range of the M3 was only 1,000 feet. The 4th also highlighted the prime concern of the pilots—gun dependability—noting that most pilots would prefer a 20-mm cannon "providing that it is dependable and will deliver a minimum cyclic rate of 1,500 rpm. If it has a high percentage of stoppages, pilots here would prefer to keep the M3 ... and keep pressure on for [getting a more powerful engine] to put the airplane within range where the .50s are effective."[256]

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[253] Smith to Commanding General, Far East Air Force, "Combat Evaluation of the MiG-15." Smith was unsure if the results were due to the MiGs' "low volatile fuel", "high performance", or "ability to absorb gun fire."

[254] Hinton and Wingo, "Analysis of Operations at Kimpo," 30; Futrell, *USAF Operations in the Korean Conflict, 1 Nov 1950 - 30 Jun 1952*, 118.

[255] Meyer to Commanding Officer, 4th Fighter Interceptor Wing, "F-86-A5 Armament"; Eagleston to Commanding General, 4th Fighter Interceptor Wing, "Recommendation Concerning Armament Equipment"; Nuckols, *SNL A-57 Gun Machine Cal .50 M3*.

[256] Gabreski, "(End of Tour) Report," 7; Thyng, "Operation of the 4th Fighter Wing in Korea," 7; Baker, "Report on F-86 Operations," 10; Schinz, "Brief Resume of the Experiences," 5; Preston to Commanding Officer, 4th Fighter Interceptor Wing, "Analysis of F-86 Fighter Encounter," 6; Hise, "F-86E versus MiG-15 in Korea," 19–20.

In January 1953, as part of Project Gun Val, the Air Force began looking at replacing the Sabre's armament with the sought-after 20-mm cannons. Eight specially modified F-86s armed with the T-160 20-mm cannon subsequently flew 284 combat sorties with the 4th Wing. The combat statistics for the 20 mm-equipped Sabres—hits on twenty-one MiG-15s, destroying six, probably destroying three, and damaging twelve—were slightly better than the standard .50-caliber armed F-86s, but not significantly. Of greater interest were the twenty heart-stopping compressor stalls that the Gun Val Sabres suffered when firing their 20-mm cannons. The Air Force concluded that, while the 20-mm gun system showed some promise, between its reduced ammunition load and the troubling compressor stalls, it was not ready for worldwide deployment. Sabre pilots would continue to rely on their .50-caliber machine guns for the duration of the Korean War.[257]

Maintenance Headaches and Training Issues

Aside from the ineffective ordnance and the new sight's design limitations, pilots' number one compliant about their armament system in late 1951 and early 1952 was that it simply didn't work. Prior to the F-86E's arrival, maintenance troops were already struggling to keep the Mk-18s in the F-86As properly serviced. The introduction of the significantly more complex A-1C(M) sight and its APG-30 radar aggravated the problem, and the reliability of the gunsights plummeted. On one of his first missions in Korea, Mahurin was zeroing in on a MiG when "all of a sudden the light in my gun sight went out.... In desperation," he recalled, "I kept blazing away, blindly hoping that one stray bullet might hit the MiG"; none did.[258] On several occasions, Evans lined up behind a MiG target and fired away with his guns only to later discover that his sight was also inoperative.[259]

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[257] Hone, "Korea," 469; Werrell, *Sabres Over MIG Alley*, 19–23; Futrell, *United States Air Force in Korea*, 253, 651; Alper and Caywood, *Weapons for Fighter-to-Fighter Engagement*, 16; *Project Vista*, C:App. 76; Futrell, *USAF Operations in the Korean Conflict, 1 Jul 1952 - 27 Jul 1953*, 63–64; *FEAF Report on the Korean War*, II:173–74; *Final Report on Combat Suitability Test of F-86F-2 Aircraft with T-160 Guns*; Baker, "Report on F-86 Operations," 10; Schinz, "Brief Resume of the Experiences," 5; "Standard Aircraft Characteristics: F-86E," 3. FEAF cautioned that the "higher percentage of enemy aircraft destroyed or damaged" during Gun Val "was [probably] due in part to the skill and experience of the test pilots, and to the favorable combat positions flown on the test missions." During the test, the 20-mm guns had only 115 rounds of ammunition each, whereas the Sabre's standard ammunition load for the M3 was 300 rounds each. Schinz also noted that the introduction of the T-160 would demand increased "fighter gunner proficiency," placing a heavy burden on the state-side F-86 training program. For footage of the Gun Val test, see the silent film *Project Gun-Val.*

[258] Mahurin, *Honest John*, 41.

[259] Evans, *Sabre Jets Over Korea*, 73, 133, 169, 190. Evans once described trying to operate the sight as "trying to stack one billiard ball on another.... The damn sight image kept floating around on my windshield and

The problems the Air Force experienced in Korea with its new equipment were not unforeseen. When the A-1C(M) began to appear in Air Force aircraft months prior to the Korean War, commanders complained that their squadrons were unprepared for the new gunsight. For example, after one training exercise in January 1950, one squadron concluded that its "present personnel are definitely inadequately trained and equipped to maintain the [A-1C(M)] sight."[260] MIT Instrumentation Lab representatives on-hand to watch the exercise were appalled to see that the unit had "no written operating instructions" for the sight, no personnel trained to maintain the sight, and no test equipment for the sight. Months later, after observing the USAF Gunnery Meet in March and April 1950, the MIT engineers again warned of the pressing need for "additional devices for ground and flight checking the A-1C sight systems"; otherwise they risked squandering the finite time they had to instill in the pilots "a high degree of confidence in [the sight's] ability."[261]

Inexperienced personnel, shortages of critical components, and inadequate testing equipment would dog the A-1C(M) system throughout its time in the Korean War. Nearly twelve months after the engineers' first prescient warnings, the same problems remained, now exacerbated by wartime pressures and long-distance supply routes from the States. Reflecting on the situation "from mid-1951 to mid-1952," FEAF concluded that F-86 "sight maintenance was extremely poor."[262] The early, trickling replacement of F-86Es for F-86As on a one-for-one basis only exacerbated the chronic shortages of A-1C(M) trained personnel, parts, and testing equipment at the Sabre bases.[263] For example, Meyer complained in May 1951 that "the arrival of six aircraft with A1C gunsights created an immediate problem since" he had "only three trained maintenance personnel," was missing

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wouldn't erect.... When I pulled Gs the reticle would drop down out of sight and then float up at the side. Was I steamed!" See also Howard et al., "FEAF Intel Form 1, 16 Oct 1951 (0401)," 16; Hallion, "Air Dominance," 36–37.

[260] McClure to Commanding General, Continental Air Command et al., "Unit Operation and Analysis Report on A-1-C-M." The unit did not fly F-86s, but rather F-84E Thunderjets.

[261] Greene to Commanding General, Continental Air Command, January 31, 1950. Despite all these issues, the MIT representatives proudly noted, "Experienced pilots state that they have obtained better gunnery results with the A-1CM than with any other equipment they have used." Olsen to Holland, Schwarze, and Rhame, "Evaluation of Results."

[262] *FEAF Report on the Korean War*, II:11. See also Watts, *Operational Survey of Type A-1CM*, 4; Upson, interview.

[263] Futrell, *USAF Operations in the Korean Conflict, 1 Jul 1952 - 27 Jul 1953*, 64–65; Schinz, "Brief Resume of the Experiences," 2–3; Gabreski, "(End of Tour) Report," 6. The equipment shortages were not confined to A-1 components; however, the A-1 situation was especially egregious. Futrell noted that "spare parts, spare components, and test equipment [for the A-1C] did not reach the Far East until at least six months after the sight was first put into use in mid-1951."

"approximately 40% of the testing equipment," and had "no stock level of spare parts."[264] The sudden influx of new F-86Es after Vandenberg's October 1951 decision added more aircraft and some additional parts, but it did little to address the supply and maintenance backlog.

When skilled maintainers, parts, and testing equipment were found, inadequate design of the A-1C(M) for rough wartime operating conditions and poor modular integration of its APG-30 radar hampered timely repair. MIT had designed the sight to be maintained and calibrated in a carefully temperature-controlled building, yet none of the Korean air bases had one. Nor were the gunsight's "fragile" mechanical linkages designed to be bounced along a rough, steel-planked Korean runway several times a day. Complicating maintenance requirements, ground technicians soon learned that when one electronic component in the radar failed, the entire radar system needed to be replaced, "not just the faulty module."[265] Gabreski reported that in February 1952, more than 60 percent of the 51st Wing's A-1C(M) gunsights were unserviceable.[266]

Many of the mechanical deficiencies of the A-1C(M) were eventually corrected in its A-4 successor, which was incorporated into the F-86F that began arriving in Korea in late 1952.[267] However, for the F-86E pilots and maintainers stuck in Korea in early 1952, the A-1C(M) proved a constant headache. Gabreski lambasted the A-1C for its burdensome financial and personnel requirements, noting: "It may be brought to light that the gross value of equipment needed to maintain an A-1CM gunsight is approximately $256,595.52. This is to support 58 aircraft, and only includes the cost of test equipment. In addition to the prohibitive price of test equipment, it is estimated that it takes approximately 10,000 man hours per month to maintain the A-1CM sight systems in 58 aircraft." In February 1952, the

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[264] Meyer to Commanding General, Air Defense Force, "F-86 Activities Report," 2.

[265] Futrell, *USAF Operations in the Korean Conflict, 1 Jul 1952 - 27 Jul 1953*, 64–65; Wildenberg, "A-1C(M) Gunsight," 34; *Accelerated Comparison Test*, Inclosure 1, 2; Werrell, *Sabres Over MIG Alley*, 28; Greene to Commanding General, Continental Air Command, January 31, 1950; Hise, "F-86E versus MiG-15 in Korea," 20; Evans, *Sabre Jets Over Korea*, 128. Regarding the rough runway conditions, Evans described Kimpo's as "rough as a cob from all the old bomb and shell crater patching and endless repairs."

[266] Gabreski, "(End of Tour) Report," 6.

[267] "A-4 Sight"; McNickle to WCSWF, "Reworking A-4 Sightheads"; Tucker, "Fire Control"; Werrell, *Sabres Over MIG Alley*, 29; *History of the 4th Fighter-Interceptor Wing, Jul - Dec 1952*, 35; "Standard Aircraft Characteristics: F-86F," 3; Futrell, *USAF Operations in the Korean Conflict, 1 Jul 1952 - 27 Jul 1953*, 65. The A-4 was described as a "a dressed up A-1." Regrettably, many of the errors that accompanied the fielding of the A-1C were repeated with the A-4.

director of operations at Fifth Air Force declared that the A-1C(M) sight was "too complicated to be maintained." A month later, another officer in Fifth Air Force reported that "the majority of F-86E pilots have little faith in the sight."[268]

With the uproar over the poor condition of the new sights reaching a crescendo, officials at Air Materiel Command, spurred by the commander of Fifth Air Force, finally launched a comprehensive program to rehabilitate the A-1C(M) and its accompanying APG-30 radar. The program was known as Project Jaybird. A group of Air Training Command (ATC) instructors and military and civilian technical specialists spent nearly three months beginning in April 1952 traveling through Japan and Korea repairing the faulty gunsight and radar equipment while simultaneously offering in-depth training on the system to both ground maintenance personnel and pilots.[269] It took "a considerable amount of work … to put the sights in proper condition," the Jaybird technicians reported after the program. "About half of the sights required some attention," and, because of the system's poor modularity, any malfunction, "however minor, was sufficient to make the sight inoperative."[270] It was during Project Jaybird that the A-1C(M) sights were modified to accommodate Jenkins's range limiter.

While the Jaybird team was working to restore and upgrade the in-theater sights, officials at Fifth Air Force vowed to tackle the supply issues that had also contributed to the dramatic decline in the system's combat functionality. They revamped the command's supply processes to guarantee the acquisition and retention of adequate on-hand bench stock and the quick replenishment of hard-to-find critical sight components and testing equipment.[271]

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[268] Futrell, *USAF Operations in the Korean Conflict, 1 Nov 1950 - 30 Jun 1952*, 119; Futrell, *USAF Operations in the Korean Conflict, 1 Jul 1952 - 27 Jul 1953*, 65; Gabreski, "(End of Tour) Report," 6–7.

[269] *FEAF Report on the Korean War*, II:11; Futrell, *USAF Operations in the Korean Conflict, 1 Nov 1950 - 30 Jun 1952*, 119; Werrell, *Sabres Over MIG Alley*, 28; Wildenberg, "A-1C(M) Gunsight," 34; Futrell, *USAF Operations in the Korean Conflict, 1 Jul 1952 - 27 Jul 1953*, 65–66; *History of the 4th Fighter-Interceptor Wing, May 1952*, 51; *History of the 51st Fighter Interceptor Wing, May 1952*, 10; *History of the 6400th Air Depot Wing, Feb - Jun 1952*, I:153. The exact timing of Jaybird is disputed in the cited sources, but all agree that the majority of activity took place between April and June 1952. Mimicking the necessity and eventual success of Jaybird, Air Materiel Command would initiate Project Sightline in February 1953 to rehabilitate the A-4 sights in the field.

[270] *FEAF Report on the Korean War*, II:11; Wildenberg, "A-1C(M) Gunsight," 34; *History of the 6400th Air Depot Wing, Feb - Jun 1952*, I:114, 261. The F-86 depot unit reported that "605 units were modified and processed" as part of Project Jaybird.

[271] Werrell, *Sabres Over MIG Alley*, 29; Schinz, "Brief Resume of the Experiences," 2–3. Occasionally, circumstances beyond human control seemed to conspire against the gunsights: in April 1952, the "Group Radar and IFF Shop [at Kimpo] burned to the ground. As a direct result of the fire, [the maintenance] section was relieved of its one and only 28-volt rectifier." *History of the 334th Fighter Interceptor Squadron, Apr 1952*, 8.

In the individual units, commanders elected to consolidate all of their gunsight technicians and maintenance actions into a single group-level organization, achieving a synergy not achievable when each squadron performed its own repair work on the gunsights and radars. Although not immediate, the performance of the system steadily improved under the increased scrutiny.[272]

The pilots in particular benefited from the additional, remedial training provided by the Jaybird team. After the war, FEAF officials concluded that the majority of Sabre pilots "arriving in the theater had no prior training on the sight," which in turn suggested that "a significant proportion of the difficulties [with the A-1 sight] must be attributed to improper operation."[273] It wasn't just that the pilots didn't understand the complex physics, mathematical relationships, or mechanical linkages that generated the aiming reticle on their windscreen. Rather, as a 1952 Operational Survey of the A-1C(M) discovered, only a few pilots could even anticipate how the reticle would work in a dogfight. Moreover, the pilots' poor understanding of the system exacerbated the maintenance difficulties because the pilots couldn't adequately determine when the sight was working properly and when it wasn't.[274]

The pilot's lackadaisical attitude toward the equipment that was designed to help them garner glory in the skies over MiG Alley reflected their general tendency to shun technical knowledge. Tactics manuals for the two Sabre wings in Korea both stressed that "complete familiarity with the aircraft is imperative." The 51st's manual even drew special attention to the importance of a pilot's "operating knowledge of the A-1-CM gunsight" as a "prerequisite for accurate gunnery."[275] But, recalling Evans's impromptu instruction on the A-1C(M), for the majority of pilots, adequate operating knowledge of the gunsight could be conveyed in a two-minute pitch.[276] Ultimately, pilots didn't consider it a useful allocation of their time studying in detail a system that rarely worked and that was installed in only a handful of airplanes then parked on the flightline.

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[272] *History of the 51st Fighter Interceptor Group, Dec 1951*, 13; Baker, "Report on F-86 Operations," 6; *History of the 4th Fighter-Interceptor Wing, Jun 1952*, 44.

[273] *FEAF Report on the Korean War*, II:11.

[274] Watts, *Operational Survey of Type A-1CM*, 5–6. Although Watts's report covered F-84E units, the situation was similar in the F-86 units. Watts estimated that "about 90 percent of replacement pilots arriving in Korea, to date, have had no prior training with the A-1CM gunsight."

[275] *4th FIG Tactical Doctrine*, July 22, 1951, 1; *Resume of Our Tactics*, 16.

[276] Evans, *Sabre Jets Over Korea*, 122.

After Jaybird helped restore the sights' functionality, and with their chances of using the sight increasing as more A-1-equipped Sabres populated the flightline, the pilots began to devote the necessary energy to understanding the gunsight. Reflecting its new priority (and the availability of spare parts), the crews at Kimpo in July 1952 constructed a simulator mock-up of the gunsight. The mock-up used the "exact aircraft wiring and cabling" and sight components, and was mechanized such that "stick movement would cause the same reticle movement in the mock-up as in the aircraft in flight." The 4th's officers concluded that the new apparatus would "be a valuable training aid in maintenance instruction as well as pilot instruction."[277]

Project Jaybird in mid-1952 therefore marked a turning point in the pilots' relationship with their gunsight equipment. Although the sight continued to suffer from its inherent design limitations, Project Jaybird helped restore the pilots' trust in the system. With greater reliability and enjoying the practical benefits of the range limiter, pilots that remained in combat after summer 1952 began to write more approvingly of their A-1C(M) gunsight, and they expressed optimism about its A-4 follow-on. For example, Low remarked in a July 1952 report that his "experience with the A1CM sight has given me complete satisfaction.... The ease of operation and accuracy are two of the best points of the A1CM." Affirming the sight's original promise, Baker remarked that he especially liked the way the "sight takes all the work off of the pilot and allows him time to concentrate on positioning."[278] Even Cleveland remembered the A-1 working "to perfection" during his first MiG encounter on July 11, 1952.[279]

But for the pilots that flew with the A-1C(M) and finished their tours before mid-1952, before Project Jaybird, there was little appreciation for the sight. Pilots "complained about the gunsight's unreliability, high maintenance requirements, and excess weight."[280]

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[277] *History of the 4th Fighter-Interceptor Wing, Oct 1951*, chap. 6; *History of the 51st Fighter Interceptor Wing, Feb 1952*, chap. 2; *History of the 4th Fighter-Interceptor Group, Jul 1952*, Maintenance, Supply, Communications, and Armament; *History of the 4th Fighter-Interceptor Wing, Jul - Dec 1952*, 70–71.

[278] Baker, "Report on F-86 Operations," 6; "He's a Poor Shot, Says Top Jet Ace." The *New York Times* reporter noted the marked contrast in Baker's appraisal of the system: "Unlike another jet ace who said recently that he had shot down eight planes by using 'Kentucky windage' rather than the gun sight, Colonel Baker classified himself as a rather poor marksman. He said that in making his kills he had to get close to the enemy and use the radar gun sight entirely." See also Thyng, "Operation of the 4th Fighter Wing in Korea," 5.

[279] Trest, *Once a Fighter Pilot*, 80.

[280] Werrell, *Sabres Over MiG Alley*, 29; Wildenberg, "A-1C(M) Gunsight," 34.

Colonel Albert Schinz, Gabreski's deputy in the 51st, concluded in his postwar report, dated July 10, 1952, "It is very doubtful that this sighting system, as difficult to maintain as it is, will be of much value for world-wide application."[281] Gabreski, who finished his postwar report just days before Schinz, was one of the A-1's most vocal critics. At one point, Gabreski reportedly remarked that he preferred using "a piece of chewing gum in the windshield" rather than the "intricate, highly complicated electronic equipment" in the radar-ranged gunsight.[282] It was Gabreski, the Air Force's premier two-war ace with 34½ kills, 6½ of those earned in the Sabre over Korea, that led the charge later that summer to convince the Air Force Chief of Staff to kill the radar-ranged gunsight.

Deciding the Future of Advanced Fire Control Systems

The fourteen aces that confronted the CSAF in summer 1952 were determined to rid the Air Force of the troubling A-1C(M) gunsight, its APG-30 radar, and the A-4 follow-on. Fresh from their Korean assignments, where they repeatedly had to wait for a high-flying MiG to pounce before they could attack, only to be then thwarted by a faulty, unreliable, and "too sophisticated" gunsight, the aces thought they had an obvious solution to their frustrations. Eliminating the complex and, in their experience, rarely functioning radar-ranged gunsight would yield a simpler and therefore more maintainable armament system. Its removal would also lighten the F-86, thereby boosting the Sabre's acceleration performance and maximum ceiling, which the pilots could then use to outduel the MiGs at altitude. Following the meeting, General Vandenberg summarized the aces' position: since "an extremely high percentage of kills will be at short range … during a stern chase, … it is most unwise to burden our fighters with 205 extra pounds of gunsight complexity and unreliability to take care of the rather remote chance of a long range, high deflection kill."[283]

Furthermore, several pilots had also complained of additional too complex gadgetry, beyond the gunsights, crammed into their fighters.[284] For example, in his final report from

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[281] Schinz, "Brief Resume of the Experiences," 3.

[282] Gabreski, "(End of Tour) Report"; Wildenberg, "A-1C(M) Gunsight," 35; Werrell, *Sabres Over MIG Alley*, 30. See also Gabreski's comments on the need for "simplicity of design" in Gabreski, "Our Top Ace Talks Shop," 41.

[283] General Vandenberg's message is quoted in CG FEAF to CG AF FIVE, "Personal from Smart to Barcus."

[284] This was not a new problem. For example, an air pursuit text from 1929 declared: "Aircraft performance is the essence of all aerial warfare, offensive or defensive. In the air, speed and climb are, in the present state of affairs, infinitely more valuable to pursuit than the number of guns or the weight of projectiles. Only sufficient

Korea, Schinz complained of the "many safety upon safety provisions" unnecessarily weighing down the F-86, features that might be fine for a "State-side fighter" but, when "under combat conditions," rendered an airplane "unsafe." The vice commander of Fifth Air Force, General James Ferguson, also warned that the Air Force's "penchant for gadgetry and the practice of providing alternate systems and electronics instead of mechanical controls has reached a point requiring re-examination."[285]

Responding to the aces' criticisms regarding their gunsight, on September 4, 1952, the CSAF ordered his testers to conduct an immediate and accelerated comparison of the service's radar-ranged and non-radar-ranged gunsights. Since the A-1C(M) was already in the process of being replaced, the newer A-4 gunsight with the APG-30 radar (now collectively referred to as the J-2) was used during the test. The Air Force selected its venerable K-14 as the non-radar ranged gunsight. Scarcely three weeks later, Major General Patrick Timberlake, Commander of the Air Proving Ground at Eglin, concluded that, along with the A-4, "the APG-30, even in its present state, should be retained in existing air superiority fighters," and that "efforts to improve the reliability of the APG-30 radar should be intensified."[286] In recommending retention of the radar, Timberlake was effectively vetoing the recommendation of six of the pilots that flew in the test.

The pilots, Colonels Gabreski and Meyer, Majors Whisner and Jabara, and First Lieutenants Kincheloe and Kasler, quickly reached two conclusions: the old K-14 gunsight was wholly inadequate; and the A-4 was a significant improvement over the A-1C(M). However, the APG-30 radar still proved problematic, so the pilots began investigating whether the A-4 should be fielded with or without its radar. They concluded in favor of the latter, recommending "the APG-30 Radar be deleted as a requirement for air superiority fighters and a gyro sighting system such as the A-4 be utilized with stadiametric ranging." While acknowledging the "JAYBIRD fixes," the pilots concluded that the radar "is still not suitable for use in the F-86E due to its unreliability, limited performance at low altitudes, inadequacy against jet fighter targets, erratic performance in the presence of clouds,

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power to destroy without being destroyed is necessary. When pursuit aircraft are properly designed almost everything is sacrificed to the one essential—performance." *Pursuit Text*, 88.

[285] Futrell, *USAF Operations in the Korean Conflict, 1 Nov 1950 - 30 Jun 1952*, 117; Schinz, "Brief Resume of the Experiences," 5. The commander of Fifth Air Force, General Weyland, also warned, "More attention should be paid to keeping the weight of our aircraft to a minimum."

[286] *Accelerated Comparison Test*, 2.

excessive maintenance and personnel requirements, etc." Furthermore, the pilots concluded that the manual-ranging and radar-ranging sights were "comparable at short ranges" where they believed the majority of combat firing took place.[287]

The fact that the test pilots' recommendation reflected the arguments against the A-1C(M) presented earlier to the CSAF was no fluke: the majority of the pilots involved in the comparison test were Korean aces—Gabreski, Whisner, Jabara, Kincheloe, and Kasler all achieved ace status by the summer of 1952.[288] Their assessments of the radar reflected their earlier distasteful combat experience with the A-1C(M). In the test report, for example, Gabreski focused on his ordeals generating sufficient numbers of F-86s while commanding the 51st FIW at Suwon, and he warned that the "intricate, highly complicated electronic equipment" in "the radar section of the J-2 system ... will create a terrific maintenance problem in the field." Jabara criticized the radar's poor performance in the air, commenting, "At close ranges, approximately 700 ft., my radar would break lock.... It is very disheartening to me to have my radar break lock ... at those close ranges because that is when I am actually effective."[289] Of note, Lieutenants Kincheloe and Kasler based their recommendations solely on their combat experience; the report notes that the two "did not arrive" at Eglin "in time to participate in the flying portion of the test."[290]

Only one test participant, the 4th's former wing commander, Meyer, seemed to display a concern for future armament requirements, suggesting that in "future programming, ... with the increased speeds of aircraft in the air superiority field, and with the direction toward increased caliber of weapons and shorter time of fire, a very real requirement exists for automatic ranging features in future air superiority aircraft." Although he signed the report indicating that he concurred with its "evaluation, conclusions, and recommendations," Meyer's individual comments offered a dissenting recommendation:

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[287] Ibid., Inclosure 1:5, 7–8, Inclosure 2:2. Johnston and Green flew in the test but did not sign the report, apparently indicating their dissension. The report noted that "the 'J' [radar-ranging] System has the capability of scoring a relatively high percentage of hits at long ranges whereas the performance of the K-14 is known to be extremely limited at ranges in excess of 1200 feet."

[288] Futrell, *USAF Operations in the Korean Conflict, 1 Jul 1952 - 27 Jul 1953*, 61.

[289] *Accelerated Comparison Test*, Inclosure 1, 5–6. Whisner similarly focused his comments on the poor reliability of the system, conceding that "if the radar was reliable to a percent of 90 to 95, then each of us would say that we would buy it, in spite of the weight, expense, and problems involved," but he also decalred his doubts that "we can get adequate reliability into this gunsight system."

[290] Ibid., Inclosure 2:2.

"that automatic ranging features of an improved design to the APG-30 be included in the requirement for all air superiority fighter. Further, that those fighters presently equipped with APG-30 continue to use them" while "imposing maximum effort" on enhancing "reliability and maintainability as well as improved performance of automatic ranging features."[291]

Timberlake and his subordinates at the Air Proving Ground sided with Meyer. First, testing officials noted that the aces' hopes of quickly lightening the Sabre by removing the radar set were misplaced; removing the equipment would require adding ballast to the nose of the aircraft to maintain its proper center of gravity. More significantly, Timberlake declined to base his recommendation on the pessimistic recollections of a handful of Korean aces and the test's orchestrated firing passes against a slow banner target, which he noted "is not realistic or comparable to fighter vs fighter combat."[292] Using a collection of Korean air combat gun camera footage, researchers working on contract at the University of Chicago and the Museum of Science and Industry concluded that "the bulk of the firing in combat is conducted at ranges and angles off in excess of 1500 feet and 10°..... At these conditions," Timberlake's cover memorandum read, "the kill probability using the A-4 sight with radar ranging is twice that attained with either the A-4 or K-14 sights with manual ranging."[293]

Timberlake was also not without support from the field when he chose to dismiss the aces' arguments. When Vandenberg ordered Eglin to initiate the test, he also asked for a new round of input from the current Korean aviators, men who had more experience with the sights post-Jaybird. Forwarding the Chief's request on, a FEAF-to-Fifth Air Force message noted, "it is probable the 14 aces Gen Vandenberg referred to were not well trained on the A-1C sight prior to arriving in Korea and were possibly serving in Korea during the period of time that maintenance difficulties prevented the full effectiveness of the A-1C

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[291] Ibid., Inclosure 1:5–6.

[292] Ibid., Inclosure 1:1–3. The report noted: "The only known 'yardstick' for determining the relative accuracies of the various system are results of firing on banner targets. The shortcomings of this method are well known, the two principle ones being the slow speed of the target and the fact that firing must be accomplished at an angle off in excess of 15 degrees which is not realistic or comparable to fighter vs fighter combat. These limitations must be borne in mind when evaluating the results."

[293] Ibid., 1–2; Strauss, *Analysis of Korean Air-to-Air Combat Film*, 7. Emphasis in original. While the University of Chicago study determined that the majority of firing passes were made from outside the stern position and at long range, it also concluded that "the most effective attack, in terms of hits, was from an angle-off of less than 15° and a range of about 600 feet."

sight. Perhaps the newest crop of jet aces might have different views on sight effectiveness."[294] They did.

In a report dated September 17, nine days before Timberlake penned his cover letter for the final test report coming from Eglin, the "'present crop' of jet aces ... well versed in the use of the A1CM gunsight through all phases of operation including its present improved operation as against its period of unreliability earlier this year" argued that "all of the automatic features of the A1CM gunsight should be retained." The pilots reasoned that while an experienced combat pilot might achieve good results with "a Mark 18 type sight, the superior pilots are the exception rather than the rule." As Meyer did, the current FEAF pilot-aces looked toward the future and concluded that soon, younger and more inexperienced pilots would be flying fighters, and that they would "need, to be effective in the air superiority role, all of the automatic features afforded by the A1CM sight." Moreover, the FEAF pilots concluded that "with the improved armament expected in the near future" and a more aggressive enemy, "high deflection shooting" and an "automatic computing, automatic ranging sight" would "become much more important." Hence, they argued, "removing the A-1CM gunsight" would be a step "backward instead of forward," irreversibly hindering the "development of tactics, training and employment of an automatic ranging and computing gunsight for use in any future conflict."[295]

The Air Force in the end elected to continue fielding the J-2 (the A-4/APG-30 combination) in its F-86 Sabres. Later, the J-2 would be redesignated the MA-3, and it would go on to equip the follow-on to the Sabre, North American's F-100 Super Sabre, which entered service in fall 1954.[296] The radar-ranging gunsight survived not because of its performance in the rough-and-tumble air combat environment of Korea, but in spite of it. After the war, the Air Force's Materiel Command "conceded that the decision to produce the A-1C sight had been a little premature, considering its state of development."[297] Even by 1956, issues with the complex APG-30 radar remained. That year, Jenkins authored an article for *Fighter Weapons Newsletter*, in which he acknowledged that "airborne range-only radars ...

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[294] CG FEAF to CG AF FIVE, "Personal from Smart to Barcus."

[295] Hale to Commanding General, Far East Air Forces, "A1CM Gunsight"; *FEAF Report on the Korean War*, II:12; Futrell, *USAF Operations in the Korean Conflict, 1 Jul 1952 - 27 Jul 1953*, 66; Werrell, *Sabres Over MIG Alley*, 30–32. Hale's report summarized a September 11 meeting of the aces.

[296] Long, *USAF Fighter Aircraft Fire Control Systems*.

[297] Futrell, *USAF Operations in the Korean Conflict, 1 Jul 1952 - 27 Jul 1953*, 64.

are heavy, bulky, costly, difficult to maintain, unreliable and erratic in operation." But, he countered, "The only subject ... that's more revolting than radar ranging is manual ranging."[298] The decision to continue developing the radar-ranged gunsight represented a choice for the Air Force between the lesser of two evils, but it also depended on the shift in pilots' attitudes that occurred in mid-1952. The pilots' acknowledgement that they needed technology's aid, and their new willingness to learn how to use that technology, combined with the new emphasis on properly maintaining the sight and its adaptation to better serve the conditions of Korean air combat, allowed the gunsight and the pilot to evolve into a more effective human-machine system.

Conclusion

After having battled the MiGs for months, the 4th's Group commander, Lieutenant Colonel Glenn Eagleston, in July 1951 declared to his fellow Sabre pilots:

> The prevalent, but extremely uneducated, "school of thought" that the fantastic speeds, fuel, and altitude problems would eliminate the possibility of aerial combat, jet vs jet, has been summarily squelched by the scorching, kerosene consuming, maneuvering, 50 plane mass dog fights over the Yalu River. When two or more aggressive fighters meet in the sky and sufficient determination is maintained by the pilots concerned to desire a positive decision as to who is the victor, a maneuvering "dog fight" will ensue and continue until the decision is made self-evident by the withdrawal, damage to, or destruction of one or more of the participants.[299]

Jousting in the topsy-turvy, slashing, high-speed aerial battles, frequently outnumbered and constantly shifting back and forth from hunter to hunted, flying a comparable but not superior aircraft outfitted with a finicky and questionable radar gunsight, Korean air combat, the men were told, demanded pilots who were aggressive "tigers," aviators who possessed the requisite "guts" needed to brave unenviable odds for a shot at "glory."

The Sabre pilots sought to prove their aggressiveness at every opportunity. They boasted about their ability to fly without checklists and other aids, and, flying unprecedentedly complex aircraft, they occasionally perished because of it. Pushed to perfect their flying skills and join in alcohol-fueled camaraderie, they had little incentive to spend

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[298] Jenkins, "Some Notes," 51.

[299] *4th FIG Tactical Doctrine*, July 22, 1951, 1–2.

time studying the physics that both propelled their jet aircraft to lofty heights and that yielded an electromagnetically determined range for their gunsight. Motivated by the glory of aerial victory and the allure of acehood, they resorted to hunting MiGs in off-limits Manchuria, at times even gunning down the enemy aircraft as they landed. And although the pilots were told that they were part of a formation team—that there was no place for individuals—they quickly realized that glory always went to the leader.

Aerial warfare remained a ruthless business. The advent of jet combat had not changed that element. But now dogfights became even shorter affairs characterized by blazing fast speeds, high altitudes, quick turns, and high-Gs. In a matter of seconds, a speck on the distant horizon could transform into a massive, red-nosed MiG spewing bright orange balls of fire before disappearing back into the blue sky a moment later. Although the A-1C(M) radar-ranged gunsight was designed to aid Americans pilots in their quest to become an ace, these types of battles rendered it difficult for the Sabre pilots to use their gunsight in the manner in which engineers originally assumed it would be. There was little opportunity for the attacking pilot to align his aircraft perfectly in the target's plane of motion, nor could he always reliably track the target in a smooth and stable manner before opening fire.

Complicating matters, the A-1C(M) and its accompanying APG-30 radar rarely worked. Victims of a complex design ill-suited for wartime field repair, and languishing at the end of a long supply line, reliability of the sights plummeted, and with it, the pilots' trust in the new armament system. The advertised automaticity of the new A-1C(M) gunsight and its APG-30 radar was never realized, and when the sight failed to perform correctly, the pilot was left to intervene, relying on the same skill sets that were supposedly obviated by the new sight. The dismal state of the A-1 in early 1952 nearly led to the Air Force terminating development of all of its future radar-ranged gunsights. But then, in mid-1952, something changed, and a more effective human-machine system emerged.

On one end, the gunsight technology began to evolve. New efforts to rehabilitate the sight during Project Jaybird increased the gunsights' reliability, which helped restore the pilots' trust in the system. More importantly, the engineers working on the gunsights began to realize that the gunnery problem was more abstract and less automatic than they had originally envisioned. The pilot, they finally concluded, played a much greater role in scoring a kill than simply placing a mechanically aimed pipper over the target. The Jenkins range

limiter, which granted the pilot greater flexibility controlling otherwise-automated functions of the gunsight, was one acknowledgement of this reality

At the other end, pilots' attitudes also began to change. Like the civilian aviation movement during the interwar years, fighter aviation was beginning a slow process of democratization. The fighter pilots fighting in Korea acknowledged that there would likely not be enough supremely endowed "birdmen" ready to fly the nation's growing fleet of jet fighters in a future war. They also recognized that provided with the right training and the right gunsight, even less experienced and less gifted fighter pilots might still be able to score a kill.

Of course, the fighter pilots maintained that the new pilots still needed to be skimmed from the pool of prospective fighter pilot wannabes. The best way to carefully screen the aspiring aviators was during their tenure as wingmen. There, the young pilots received a proper schooling in the fundamentals of being a fighter pilot, not just tactics, but also the roles and responsibilities that separated flight leaders from wingmen. In Korea, the wingman formation position, once borne of tactical necessity, began to resemble a rite of passage that one needed to complete before successfully gaining entry into the fraternal guild of the fighter pilot.

Thus, despite the increasing automation and electronic gadgetry in their cockpits, which might occasionally prove useful, the fighter pilots argued that they still represented the critical link. It was their craftsmanship skill, which was incapable of being reduced to engineering equations or checklist procedures, that determined victory. After all, as Jabara reminded people, "A fighter is simply an airborne gun platform. The pilot must turn, dive and climb to get into position to fire."[300] Evans likewise proudly stood up one day in front of a group of the Sabre's designers and affirmed, "But isn't the pilot the really decisive factor anyway?"[301]

As the 4th's tactical manual explained, it was the fighter pilot that had to possess "complete mastery of his aircraft" so that *he* could "get maximum effective performance out of his ship in order to defeat the enemy in maneuvering battles." *He* had to be able to "direct his fire expertly into the enemy aircraft." To declare "mission accomplished," *he* had to

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[300] Jabara, "We Fly MiG Alley," 27.

[301] Evans, *Sabre Jets Over Korea*, 196–97.

perform each function perfectly and without hesitation, from "the initial sighting of the enemy," through "the maneuvering phase [and] positioning." Only then could *he* commence "firing" and send the MiG smoking toward the ground.[302] The A-1C(M), even if it worked perfectly, could only offer hope for the final "firing" phase. But, the pilots eventually reasoned, why not accept help in that final phase if it might widen the potential pool of future MiG-killers.

Ultimately, in spite of the new automated tools in their cockpits, it was easy for the Sabre pilots of the Korean War to sustain the still-cherished, still-popular fighter pilot myth that emphasized the individual glory of aerial victory won by a pilot's supreme skill and daring. In this light, the battles fought in the skies over Korea didn't seem much different from those fought by the hard-charging Mustangs over Germany scarcely a half-decade earlier, or those fought by the fabric-covered biplanes three decades before that. Similarly, the new generation of jet fighter pilots appeared little-changed from their brave and noble forebears, still specially endowed men with eagle-like eyesight and superb flying skills. These men were not scientists; they were clearly aerial knights still looking to capture glory in the air.

A little more than a decade later, though, the fighter pilot would be confronted with even more automaticity in the McDonnell F-4C Phantom II and its strictly guided-missile armament. To cope with the new fire control systems, the fighter pilot would also have to open his cockpit to another person, a GIB—a "guy in back." And to exploit the new technology, he would be challenged to adjust the traditional formation responsibilities that had historically guided the development of young fighter pilots. Collectively, these developments would require additional changes in the fighter pilot and his machine.

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[302] *4th FIG Tactical Doctrine*, July 22, 1951, 1–3.

Chapter 4

Phantoms over Vietnam: The "GIB"

> *We felt like young tigers and now we were going to be put in the back seat with another guy. We were told, "You're in the back seat. Learn something. The guy in the front has got all the experience." So we accepted it. And the guys in the front treated us pretty nice.... The front seaters even had a pet nickname for us. They called us "GIB." They said it stood for "Guy in Back." ... We were proud to be a GIB. However, I must admit that some years later I was flipping through a real thick* Websters, *and I happened to chance upon the word gib. G-I-B, it was in there, and the definition they had in there was a "castrated tomcat."*
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> —Colonel Howard J. Hill, USAF (Ret.), 1991

It was late December 1966 and First Lieutenant Charles "Charlie" Clifton had just returned from his ninetieth mission flying over North Vietnam (NVN). That evening, he joined his squadron-mates at the bar to celebrate the milestone. Considering the standard practice of not sending a pilot with ninety missions under his belt back to Route Pack 6, the most heavily defended area around Hanoi, Clifton expected his last ten missions to be a little less harrowing. A few close calls earlier had left the twenty-four-year old's aircraft riddled with holes and metal shrapnel, earning him the nickname "Magnet Ass." The evening's revelry, however, was abruptly interrupted when two military policemen escorted the lieutenant out of the bar and told him to report to the wing commander immediately. Clifton raced off. He found the colonel in a large auditorium, giving a mission brief to a packed audience. Clifton sheepishly entered the room at the back, but the colonel saw him and halted the presentation. He walked over to Clifton, put his arm around the lieutenant's

shoulder, and said in a hushed tone, "I know you just completed your ninetieth, but I'd like you to come with me on this one."[1]

Born in Toledo, Ohio, in May 1942 but raised in Fort Wayne, Indiana, Clifton graduated from the US Air Force Academy in Colorado Springs, Colorado, two years earlier in June 1964. Not an especially stellar student, Clifton once remarked that he "majored in graduation." After the Academy, he went straight to pilot training at Laughlin AFB in Del Rio, Texas. There, he said, he learned the secret of being a fighter pilot: "It's not just learning to fly an airplane, it's being able to climb in the cockpit and feel like you're getting dressed, like you just got out of the shower and put on a 'fresh skin.'" Clifton performed well enough to earn an assignment in the F-4C Phantom and, after training at MacDill AFB, Florida, he was off to Vietnam in July 1966 as a member of the "Triple Nickel," the 555th Tactical Fighter Squadron (TFS). Now ninety combat missions later, Clifton was looking forward to whisking his "very pregnant" wife off to his next assignment in beautiful Spangdahlen, Germany.[2]

Upon hearing the colonel's request, Clifton didn't hesitate. "You got it, Boss," he replied. The mission was going deep into NVN, within twenty miles of Hanoi and directly over the large MiG airbase at Phuc Yen. A few days later on the morning of January 2, 1967, after the wing commander had issued a last, rousing, "OK, you Wolfpack, let's go get 'em!", Clifton climbed the boarding steps up into his McDonnell F-4C Phantom II and strapped himself into the pilot's seat. The aircraft was configured solely with air-to-air missiles for the mission. There were four twelve-foot long, 380-pound, radar-guided AIM-7E Sparrow missiles snuggled into the recesses carved into the belly of the Phantom. Another four smaller, IR-guided AIM-9B Sidewinder missiles were hung under the wings near the fuselage, two on each side, attached to the aircraft's inboard pylons. Farther away from the fuselage on the left outboard pylon hung a large, 370-gallon external fuel tank. A larger 600-gallon fuel tank was suspended under the aircraft's fuselage along its centerline. Normally there would have been another 370-gallon fuel tank on the right outboard pylon, but for the first time during the war, it was replaced by a small, cigar-shaped QRC-160 electronic

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[1] Clifton, "There I Was...Part 1." The Route Pack structure of the air war in Vietnam will be discussed in more detail later in this chapter. The Wing commander later claimed that Clifton had only completed "eighty-plus" missions. Olds, "How I Got My First MIG," 40.

[2] Clifton, "Who Am I"; Clifton, "There I Was...4."

countermeasures (ECM) pod. Missing the nearly 2,500 pounds of fuel on the right side to counterbalance the external tank on the left side, takeoff that morning was described by one aviator as "a thrill.... You can imagine with this asymmetric load what happened to you the minute you broke ground. You just had to come in with full rudder and hope."[3]

The goal of the afternoon mission was, like Evans's years earlier, to find enemy MiGs and shoot them down. But unlike Evans in his Sabre, Clifton in his Phantom didn't need to get behind the enemy and within gun range to get a kill. First off, Clifton's F-4 had no guns. Secondly, his AIM-7 missiles could technically be launched from any angle relative to the target. Plus, with the Sparrow's ability to home in on the radar energy that emanated from the Phantom and that was then reflected off the enemy target, the radar-guided missiles could be launched from more than five miles away. It had taken another decade after the A-1C(M), but the fighter pilots in the Phantom finally possessed a system that allowed them to kill their targets at long range and with high-deflection angles, or so they thought.

Approaching the enemy airfield from the northwest at an altitude of about 15,000 feet, Clifton's Phantom was in the lead, joined by three other Phantoms as part of Olds flight. They were followed by more Phantom flights, spaced at five-minute intervals; Ford flight was next in-line behind them. Hoping to lure the MiGs to battle, the Phantom pilots that morning had disguised themselves as formations of less maneuverable F-105 Thunderchief fighter-bombers. The jamming pods slung under the Phantoms' wings were part of the ruse, since only the "Thud" had yet carried the QRC-160 into NVN. Adding to the deception, the Phantoms also adopted Thud formations, communications procedures, and typical routing into enemy airspace.[4]

The Americans weren't sure their plan had worked, though. As Olds flight passed over Phuc Yen, they still had not detected any MiGs with their Phantoms' radars, and a solid deck of clouds below them at about 7,000 feet obscured their view of the airfield. The

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[3] Clifton, "There I Was...Part 1"; Olds, "Briefing to the Staff of Project CORONA HARVEST on Operation BOLO," 16–17; Asay, Covington, and Stone, *History of Operations BOLO*; Olds, "How I Got My First MIG."

[4] The ensuing description of Operation Bolo is based on the following sources: Olds, "Briefing to the Staff of Project CORONA HARVEST on Operation BOLO"; Asay, Covington, and Stone, *History of Operations BOLO*; Olds, "How I Got My First MIG"; Boyne, "MiG Sweep"; Ow, *Mission Bolo*; Olds, *Fighter Pilot*, chap. 17; Attinello, *Air-to-Air Encounters in Southeast Asia: Account of F-4 and F-8 Events Prior to 1 March 1967*, 415–46; Futrell et al., *Aces and Aerial Victories*, 35–42; Sherwood, *Fast Movers*, 31–37; Michel, *Clashes*, 73–74.

Phantoms continued southwest "for a full minute" before starting an "erratic turn" back northwest. Rolling out of the turn, Olds 3 reported a possible radar contact seventeen-miles ahead at twelve o'clock, but then the "low, very fast" contact disappeared. The Phantoms passed Phuc Yen again; still no MiGs. Ford flight was nearing the enemy airfield and Olds flight turned to the southeast once more. According to one post-mission report, "Everything then happened at once."[5]

Suddenly, several enemy MiG-21s started streaking up through the clouds. The first emerged right behind Clifton in Olds 1. Olds 2, flying in fighting wing formation about 1,500 feet to the left of the lead Phantom, saw the MiG. So too did the members of Ford flight, one of which beat Olds 2 to the radio and called, "Olds lead, you've got two MiG-21's right on your ass." After all the careful mission planning and orchestration, it was, one pilot remembered, "a hell of a way to start a fight."[6]

Olds flight stated an immediate defensive break to the left. Midway through the turn, another MiG appeared at eleven o'clock. Clifton already had the radar set-up for a close-in engagement and locked on immediately. With a squeeze of the trigger followed by another, two Sparrow missiles dropped from the Phantom's belly and rocketed off. But then the radar abruptly broke lock and the two missiles careened off course. A third missile, a Sidewinder, was fired at the MiG ahead, but it too missed when the enemy plane dove into the clouds below.

There were now MiGs everywhere—fourteen to be exact—and the members of Olds flight, Ford flight, and the approaching Rambler flight were ensnared in a raging, fifteen-minute long aerial battle around Phuc Yen. During the melee, Olds 1 spied another MiG one-mile away off to the left, in a left-hand turn. Clifton's Phantom zoomed high above the horizon, executed a barrel roll to the right toward the MiG's tail, and pulled down into perfect position behind and below the unaware foe. From 4,500 feet away and about fifteen-degrees off the bandit's tail, Olds 1 fired two Sidewinders. The post-mission report described the result: "The MiG-21 erupted in a brilliant flash of orange flame. A complete wing separated and flew back in the airstream, together with a mass of smaller debris. The

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[5] The post-mission report from Olds 1 is included in Asay, Covington, and Stone, *History of Operations BOLO*, 39.

[6] Olds, "Briefing to the Staff of Project CORONA HARVEST on Operation BOLO," 48.

MiG swapped ends immediately, and tumbled forward for a few instants. It then fell, twisting, corkscrewing, tumbling, lazily toward the top of the clouds."[7]

Clifton later earned credit for using a Sidewinder missile to destroy the MiG that day, but he did not pull the trigger. The trigger for the missiles was located on the control stick in the front seat of the F-4C. Clifton was sitting in the "pilot" position in the back seat of the Phantom. He was a GIB, a guy-in-back. Colonel Robin Olds, the successful World War II ace and now commander of the 8th Tactical Fighter Wing (TFW) at Ubon Royal Thai Air Force Base (RTAFB), was sitting in the Phantom's front, "aircraft commander" seat during the famed Operation Bolo mission.[8]

Operation Bolo would go down in history as the Air Force's greatest single aerial victory of the Vietnam War. Masterminded by Olds, the afternoon mission claimed seven MiG-21s, more than 40 percent of the North's inventory of its top-of-the-line, delta-winged, Soviet fighters. Following the loss of two more MiG-21s in a Bolo-like ruse four days later, NVN effectively grounded its MiG-21 force from combat operations for nearly three months. For Olds, Operation Bolo cemented his status as "larger than life: a legend," and earned him recognition as "probably the greatest aerial warrior America ever produced." In contrast, Clifton's name was essentially lost to history; he retired in relative obscurity, eventually opening his own civilian flight school in California.[9] But Olds's success during Bolo would not have been possible without Clifton, just as his later aerial victories similarly depended on Lieutenants William Lafever and Stephen Crocker—his GIBs on his other victorious missions of May 4 and May 20, 1967.[10]

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[7] Statement from the post-mission report from Olds 1 is included in Asay, Covington, and Stone, *History of Operations BOLO*, 41.

[8] *T.O. 1F-4C-1; F-4 Aircrew Operational Procedures*, 1. Per the flight manuals, the front seat occupant of the Phantom was the "aircraft commander"; the rear seat occupant was the "pilot systems operator" or "pilot." However, Phantom crews typically referred to the front seat occupant as the "pilot," since he flew the plane, and the back seater as the "GIB." Adding confusion to the terminology, both occupants were, at least until a change in policy in 1969, Air Force-trained pilots—officers who had completed pilot training program and who therefore wore pilot wings on their uniform. To avoid confusion and respect the terminology of the time, I generally avoid use of the term "aircraft commander" and instead identify the occupants by their position in the cockpit, i.e. front seater or back seater.

[9] Olds, *Fighter Pilot*; Clifton, "Who Am I"; Clifton, "There I Was...4"; Sherwood, *Fast Movers*, chap. 1. Quotes are from the "Advance Praise" section of the dust jacket of *Fighter Pilot*. Sherwood titled his chapter on Olds "Old Lionheart."

[10] Futrell et al., *Aces and Aerial Victories*, 135. Olds and Crocker destroyed two MiGs on May 20, 1967, bringing Olds's final tally for the Vietnam War to four kills.

Nonetheless, the GIB's contributions to aerial victory often went unacknowledged by those occupying the front seat. For example, describing one engagement in which he "found two more MiGs way off at nine o'clock," Major Bill Kirk, who would eventually finish his combat tour with two MiG kills, stated: "*I* got behind them, *I* got all armed up, got a radar lock-on and *I* fired off two Sparrow missiles at them."[11] Similarly, Major Sam Bakke noted that on his victorious mission of May 14, 1967, "*I* must have attacked about six MIGs that day firing a missile at most of them until *I* finally did get one."[12] Reading Kirk's and Bakke's narratives, one might never realize that there was someone else seated in the cockpit with them. Nor was the attitude unique to those two particular front seaters. When recalling his second MiG kill, Olds remembered to acknowledge his wingmen, "Dick Pascoe, Kirk, and Allen," but he made no mention of his or his wingmen's GIBs.[13]

It may have been unintentional, but the denotation that accompanied the pet name for the back seaters that former-GIB Howard Hill happened upon one day while flipping through *Webster's* was not far off. Although the GIBs through 1969 were all trained pilots, they remained in the minds of many front seaters only pseudo-pilots, veritable second-class citizens within the ranks of the fighter pilot fraternity. Not quite tigers, the GIBs were indeed more like "castrated tomcat[s]."[14]

The two-seat cockpit in the Air Force's F-4C Phantom represented a profound divergence from the historic representation of the fighter pilot. Fighter pilots since the time of Garros and Boelcke had reveled in the autonomy associated with flying a single seater. The presence of the GIB sullied the historic persona of the fighter pilot as lone eagle—or in the case of Korea, lone tiger. Salter's eloquent description of the fighter pilot "as isolated as a deep-sea diver" now rang hollow, and Evans's experiences of being "sealed off to the peculiar whines and whispers of my own aircraft" were soon drowned out by the incessant

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[11] Kirk, Oral History Interview, 24. Emphasis added.

[12] Bakke, Oral History Interview, 9. Emphasis added.

[13] Olds, *Fighter Pilot*, 303–4. The Air Force's anthology of aerial victories in Southeast Asia tended to refer only to the aircraft commander in its narratives, "for the sake of convenience." Futrell et al., *Aces and Aerial Victories*, 22.

[14] Hill, Oral History Interview, 21–22. Anderegg, who also flew as a GIB during Vietnam, was unaware of the denotation associated with the term "gib," indicating that the correlation, although fitting, may have been unintentional. Anderegg, interview, October 2, 2013.

and annoying sound of another man's breathing over the "hot-mike intercom."[15] The Phantom flight manual's reference to the rear-seat, radar-manipulating occupant of the F-4C as the "pilot" added to the ignominy.[16]

The use of missiles likewise clashed with the historic fighter pilot image. Since the Great War, aerial victories were recognized as the appropriate measure of a fighter pilot's flying prowess and his skill at maneuvering his aircraft into the proper position before squeezing the trigger at the proper time. Olds and Clifton earned their victory during Bolo with a single squeeze of the trigger from more than 4,500 feet away. Scarcely a decade earlier, Sabre pilots in Korea were extremely lucky to score a hit at even one-third that distance. And Olds's and Clifton's short-range Sidewinder missile was guided by a lead-sulfide (PbS) detector that homed in on the heat plume produced by the MiG-21's jet engine and then automatically detonated the missile's warhead when it sensed it was close enough to the target to do sufficient damage. Where was the skill in that?

Even the iconic images of the aerial battles of Vietnam reflected the divergence. For example, contrast the image that celebrated Jabara's ace-victory in the Korean War (figure 3.21) with the image of Olds's and Clifton's victory in Operation Bolo (figure 4.1). The former exudes the romantic imagery of dueling dogfighters, but in the latter, the enemy is but a speck in the distance. Rather than focusing on the aerial contest or even the F-4's two occupants, the viewer's attention in Keith Ferris's "MiG Sweep" is instead drawn

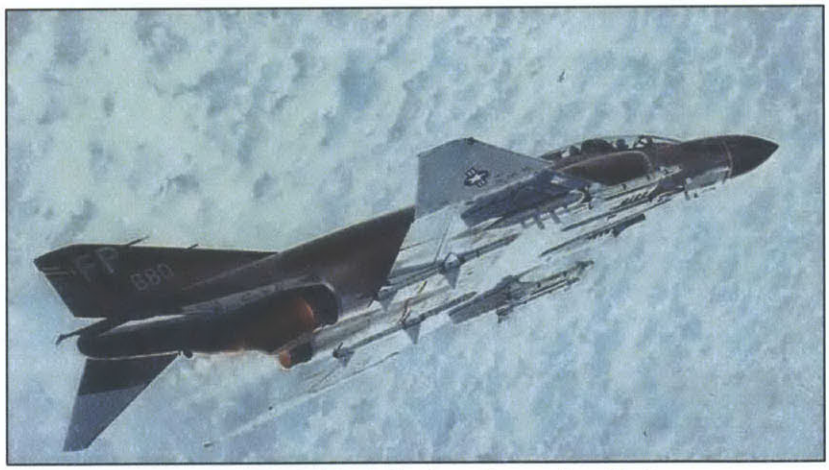

Figure 4.1. Olds 1 during Operation Bolo.
The Phantom's crew had already jettisoned their aircraft's external fuel tanks, leaving only the aircraft's missile armament and ECM pod. (Source: Cooling, *Air Superiority*; "MiG Sweep" painting by Keith Ferris)

[15] Salter, *Hunters*, 193; Evans, *Sabre Jets Over Korea*, 127; Creech, Oral History Interview, 54. General Wilbur Creech, a future commander of TAC, teased the Phantom pilots, "I've never been against people breathing in my ear, but I didn't want it to come from a back seater on a hot-mike intercom."

[16] *T.O. 1F-4C-1.*

to the brutish power of the Phantom's thundering afterburners and its gleaming white missile armament—the technological tools for the new era of air warfare encountered in the skies over Vietnam.

All told, the shift from the .50-caliber machine guns and the radar-ranged A-1C(M) gunsight of the F-86E Sabre to the rocket-propelled guided missiles and intricate fire control system of the Phantom, so complex that it required another crewmember to operate it, threatened to upend the treasured, decades-old myth of the fighter pilot. How did the Phantom aircrews respond? With all the talk of PbS IR-detecting missiles, gigahertz radar frequencies, and antenna train angles and intercept geometries, had the fabled silk scarf-wearing aviators finally morphed into the long-haired scientists (figure 1.4) that *Life* predicted in 1952, or the small, decrepit troglodytes crowded into black boxes (figure 1.3) that the fighter pilots imagined themselves as at the turn of the decade?

This chapter addresses these questions by again focusing on the human-machine relationships that emerged in the F-4C Phantom. The interpersonal relationships between the GIB and the front seater are also a central feature of this particular case. As in the prior chapter, I begin with a review of the new technology, tracing the process by which Air Force pilots in Vietnam suddenly found themselves wholly reliant on guided missiles, and how they responded to the new technical requirements that demanded two individuals be on-board to operate the more-complex weapons systems. I then look at the context of the air war in Vietnam and the pilots' growing frustration as they struggled with the requirements to perform both air-to-air and air-to-ground missions. In the air-to-air realm, the pilots' performance was dogged by the lackluster performance of their missiles in battles against the North's nimble MiGs. It was then that the Phantom crews, and especially the GIBs working the radar in the back seat, realized that the procedures wired into their equipment and codified in their manuals were at best inadequate for air combat over Vietnam. Although the Phantom's new armament systems represented a carefully crafted effort to democratize fighter aviation by automating-out the pilot's skill and transferring it to the missile, a shift encouraged by the Korean aces still flying combat in late 1952, the Phantom crews quickly learned that their success and survival demanded as much tacit knowledge as that required by the Sabre pilots years earlier, albeit of a very different variety. The final two sections of this chapter therefore investigate the pilots' and the GIBs' responses to this realization and

its implications within the Phantom cockpit, between Phantom cockpits, and within the larger Air Force organization.

A New Approach to the Gunnery Problem

When the fourteen ace pilots approached the CSAF in summer 1952, they argued the best way to gain the upper hand against the MiGs was to rip the too complicated A-1C(M) gunsight and its accompanying APG-30 radar out of the Sabre, lightening the aircraft and quickly boosting its performance. There was, however, another way. What if the Sabres' bullets could be improved? What if the bullets could be loaded with extra propellant so that they could fly higher and farther? Moreover, what if they could be made to steer while in flight, even updating their trajectory based on changes in the target's flightpath? Such a projectile might wholly eliminate the requirement to precisely solve the troublesome gunnery problem. It was an intriguing approach to the decades-old problem of aerial combat, now made possible based on advancements in rocketry and radar during the Second World War.

As the early versions of the A-1B gunsight were first being mated (rather unsuccessfully) to Air Force fighters in 1948, Air Force officers attending the Air Tactical School (ATS) at Tyndall AFB, Florida, were already receiving a one-hour lecture on the potential benefits of this alternative approach to aerial combat. "It would appear that our faster aircraft, especially ones still on the drawing board ... may be fine to carry a pilot from one point to another in a great hurry," the ATS lesson plan warned, "but may be of little or no use in air-to-air combat." There were two components to this emerging "dilemma." The first was "the effect of the high speed on the pilot," specifically his ability to solve the gunnery problem. The new A-1 gunsight was expected to help address this specific issue. The second concern was the .50-caliber machine gun armament in the fighter aircraft. The lecture complained that the gun's range was too short and the bullet's striking power inadequate. The lesson plan therefore concluded: "It would appear that a weapon of some kind is required which will enable a pilot to stand off at least 10,000 feet away and fire at a target with fatal results to that target. One such weapon is the air-to-air guided missile. As presently visualized, the missile has the following advantages over armament now mounted in our aircraft:

1. Much longer effective range
2. Controllable all the way to the target

3. Powerful enough to insure [*sic*] a kill."[17]

The quest to realize the promise of the air-to-air guided missile would consume aircraft and weapons designers for decades. Several different armament variants were developed over the ensuing years leading up to Vietnam, ranging from the unguided rockets that equipped the D-model interceptor version of the Sabre, to the Falcon missile family developed for the Air Force's "1954 Interceptor," to the Navy-developed Sparrow and Sidewinder missiles that outfitted the two-seat Phantom, which eventually found its way into Air Force inventories and then into the skies over Vietnam. As the various missiles worked their way through the development process, the fighter pilot was slowly and subtlety remolded from a brash, barnstorming aviator into a technically minded systems manager, at least in the minds of the engineers developing the new fire control systems.

Rockets, Missiles, and Radars

Three years before Air Force students sat in a windowless room at Tyndall AFB learning about the benefits of air-to-air missiles, and around the time that the Army Air Forces was finalizing its contract with MIT to develop the A-1 gunsight, engineers at Hughes Aircraft were already hard at work trying to apply the emerging lessons of German rocketry and radar-homing technology to air combat. Their efforts culminated in a test firing of the Army Air Forces' first high-speed, air-to-air missile on August 6, 1945. Ironically, a single bomb dropped by a B-29 Superfortress half a world-away that day presaged an age in which faster-, farther-, and higher-flying air-to-air missiles would assume increased importance in defending the nation from fleets of high-flying bombers determined to unleash atomic Armageddon.

Alas, the Hughes JB-3 Tiamet missile tested that late-summer morning was not a viable solution (figure 4.2). Although featuring an internal FM radar homing device, a massive 100-pound warhead, a top speed of 600 miles per hour, a range of five to nine miles, and an ability to attack an aircraft flying at altitudes of up to 50,000 feet, the "very cumbersome" 625-pound missile—"essentially a 100-pound bomb with wings"—was

[17] *Air-to-Air Guided Missiles*, 1–2. The lecture included a detailed example of the geometric problems associated with the intercept pursuit curves of high-speed aircraft, eventually concluding, "as aircraft speeds rise, it will become more and more difficult for fighters to attack other aircraft." In dismissing the effectiveness of the .50-caliber ordnance, the lecture assumed an optimistic effective range of "800 yards." It noted, "The way aircraft are being built these days it would be a very lucky round indeed that might destroy another ship." The predictions proved prophetic based on the Korean War experience a few years later.

relegated to the ash-heap of failed military prototypes after only ten test launches. Following the Tiamet's demise, the service rededicated and accelerated its efforts toward acquiring a more "'practical' air-to-air missile that could be developed within two years."[18] A flurry of missile development activity ensued. At one time, the Air Force was pursuing two separate contracts each for a fighter-launched missile (to attack bombers) and a bomber-launched missile (to attack fighters). However, the funding soon ran dry and by April 1949, only a single guided missile program remained—Hughes's Falcon missile. The first Falcons, though, wouldn't reach the field for another six years.[19]

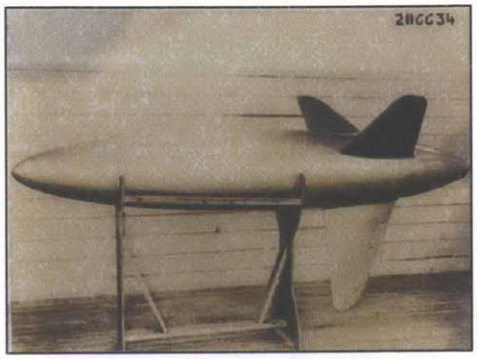

Figure 4.2. Hughes JB-3 Tiamet Air-to-Air Missile.
(Source: AFHRA)

The Air Force was also working on a new fighter that would carry the envisioned missiles. About the same time that it contracted with North American for the P-86 (later F-86) Sabre in summer 1946, the Air Force and Northrop agreed to develop the experimental P-89 Scorpion, a two-seat, twin-jet, all-weather fighter. Whereas the Sabre entered production a scant two years later, development of the F-89 languished. When the anticipated arrival of the Scorpion slid into the next decade, along with its preferred Falcon guided missile armament, the Air Force turned to Lockheed in late 1948 and requested it develop a two-seat, radar-equipped, gun-armed interceptor version of its F-80 Shooting Star, which became known as the F-94 Starfire. Later, the Air Force also contacted North American regarding the possibility of designing a version of the F-86 optimized for the interceptor role. The F-94s emerged first in May 1950. A gun-only version of the Scorpion (F-89B) appeared a year later in June 1951. The interceptor version of the F-86, the F-86D Sabre Dog (which for a brief while was known as the F-95), didn't arrive until April 1953.[20]

The Air Force's sudden thrash to field an interceptor aircraft, even if only armed with guns but still equipped with a radar that would allow its pilot to seek out and destroy enemy aircraft in any weather, day or night, was a reflection of the uneasiness that gripped

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[18] Wildenberg, "Visionary Ahead of His Time," 6; McMullen, *History of Air Defense Weapons*, 12; *Air-to-Air Guided Missiles*, 4.

[19] McMullen, *History of Air Defense Weapons*, 44, 47, 88–89; Wildenberg, "Visionary Ahead of His Time," 8.

[20] Knaack, *Encyclopedia of US Air Force Aircraft*, 1:69–111.

the nation following the Soviets' successful detonation of their own atomic bomb in August 1949. The CSAF, General Vandenberg, also lobbied aggressively for a more robust national air defense capability, which eventually culminated in the multi-billion dollar, computerized SAGE (semi-automatic ground environment) air defense system. The first SAGE site became operational at McGuire AFB, New Jersey, on June 27, 1958. Less than four-years later, twenty-one SAGE sector sites ringed the US coastline and northern border, ready to help steer American interceptor pilots toward any menacing Soviet bombers.[21]

In the interim, though, before SAGE and before the March 1956 arrival of the first F-89Hs equipped with six Falcon radar-guided air-to-air missiles, Air Force interceptor pilots took to the skies armed with a mixture of .50-caliber and 20-mm guns aimed by an A-1C(M) gunsight, now paired with an APG-33 search-and-track radar and collectively referred to as the E-1 fire control system. The pilots' chances at success, however, were not good. Sturdier and better armed enemy bombers meant that an interceptor pilot equipped solely with guns had only a one in ten chance of scoring a kill, "largely because of the interceptor's poor chance of surviving" a short-range gun attack. With the service's favored guided missiles still not ready, but with the deficiencies of its aircraft gun armament becoming more severe with each passing year, the Air Force finally decided to transition its interceptors from guns to unguided rockets. The test bed would be the new F-86D (figure 4.3), which would be armed exclusively with twenty-four unguided, 2.75-inch "Mighty Mouse" folding-fin aerial rockets loaded in an extendable tray in the belly of the aircraft. The later versions of the F-89 (F-89D) and F-94 (F-94C) quickly followed suit.[22]

Figure 4.3. F-86D Sabre Dog Interceptor.
The larger radome on the F-86D housed the steerable radar antenna. Note also the extended rocket tray just behind the nose gear door.
(Source: NMUSAF)

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[21] Redmond and Smith, *From Whirlwind to MITRE*, 19–29, 429–31. On SAGE, see also: Hughes, *Rescuing Prometheus*, chap. 2; Edwards, *Closed World*, chap. 3. SAGE relied on a network of radars and sector command centers that automatically shared, processed, and integrated air defense data using a room-sized IBM AN/FSQ-7 computer, offspring of Jay Forrester's Whirlwind digital computer developed at MIT.

[22] Knaack, *Encyclopedia of US Air Force Aircraft*, 1:69–111; Wildenberg, "Visionary Ahead of His Time," 9–11; *Pilot's Introduction to the E-4*, 4; Long, *USAF Fighter Aircraft Fire Control Systems.*

The shift from guns to rockets in the interceptor aircraft required a new fire control system to replace the now-outmoded A-1 gunsight. Moreover, unlike the systems for the F-89 or F-94, the F-86D required a fire control system optimized for use by a single pilot. Air Force officials selected Hughes' E-4 system to fill the requirement.[23] Emphasizing its sophistication and automation, one contemporary author likened the new E-4 system to a "flying IBM machine … built to calculate everything but an enemy pilot's pulse and blood pressure."[24] As to be expected, Gabreski, now serving in an administrative role at Norton AFB in California, objected to the system.[25] Nonetheless, the E-4 established the benchmark for many of the procedures and symbology used in the Air Force's later missile-equipped aircraft, including the F-4 and F-15.

The E-4's operating instructions declared that the system was made "as simple and straightforward as possible." But, for the pilots trying to fly the F-86D while simultaneously operating the radar, it wasn't. As one report noted years later, "the pilot actually needed about three arms and four eyes to perform all the functions required of him during an interception."[26] Staring at a small, circular radar scope mounted between his knees, the F-86D pilot looked for a "blip" that illuminated after the radar range trace, a vertical line that swept left and right across the display, passed over a target. Once the pilot noticed the blip, he pressed a button on the radar's hand control, a separate lever located near the aircraft throttle control, to take command of the antenna and slew the range trace line back to the azimuth of the target blip. The pilot then adjusted the radar's elevation using the same hand control until the blip achieved its maximum brightness. Releasing the button on the hand control commanded the radar to lock on to the target. To help prevent the pilot from becoming disoriented as he stared at the radar, the engineers included a separate horizon line

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[23] Wildenberg, "Visionary Ahead of His Time," 9–11; *Pilot's Introduction to the E-4*, 4; Long, *USAF Fighter Aircraft Fire Control Systems*.

[24] Miller, "Thunderbolt Geometry," 71.

[25] Gabreski, "F-86D Program Deficiencies." Gabreski, reminiscent of his previous gripes with the A-1C(M), complained in a private memo that the Air Force was "so absorbed with the prospect of technical advancement to be achieved that the capability of the Air Force to properly maintain and operate the weapons system was not kept in proper perspective."

[26] McVeigh and Perry, *Development of the F-102*, 10.

on the radar screen, but they also warned pilots that the attitude indication wasn't always accurate.[27]

Assuming the radar successfully locked on to the target, the E-4's computer calculated the necessary steering angle for the intercept and displayed a dot on the radar scope. The pilot then merely needed to maneuver his aircraft to center the dot in his scope to complete the intercept. It was difficult, however, for the pilot to maintain awareness of the target's range during the intercept, because the range trace line tended to obscure the target blip. The pilot therefore needed to keep an eye on the outer ring of the radar scope to monitor the target's range rate or closing velocity (Vc). With about twenty-seconds left in the intercept, the range rate circle would also start to decrease in size. As the circle shrank and as time to fire neared, the pilot gently leveled his wings and then pressed and held the trigger. The E-4 computer automatically lowered the tray of rockets and fired them at the appropriate time. An "X" appeared on the radar display to indicate to the pilot that the intercept was over and that he should initiate an aggressive maneuver away from the target; an important step in the procedure since, the manual noted, "the pilot cannot always rely upon there always being ample clearance between the interceptor and the target" at the end of the intercept.[28]

All told, "flying the E-4 system," the manual declared, "is like flying instruments."[29] It was a telling analogy, since flying instruments was one of pilots' more loathsome tasks. Fighter pilots rebuffed the practice when it was first introduced during the 1920s and '30s, and they continued to avoid it if at all possible even thirty-years later.[30] Many pilots found it uncomfortable to fly on instruments, trusting the round dials and wavering needles to the

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[27] *Pilot's Introduction to the E-4*. It is interesting to note that the images in the radar operating manuals only include a single, clearly distinguishable target blip. It is more likely that the radar scope would have displayed several radar returns, some from valid radar targets, others due to clutter. One pilot likened the E-4 in the F-86D to a "flying television station." Austin, Oral History Interview, 140.

[28] *Pilot's Introduction to the E-4*. See also Miller, "Thunderbolt Geometry"; Austin, Oral History Interview, 137–40.

[29] *Pilot's Introduction to the E-4*.

[30] For example, knowing that the Sabre pilots would never waste their fuel practicing instrument flying when they could be hunting MiGs, the squadrons in Korea were provided with spare T-33 aircraft for the pilots to practice their instrument flying skills. More often than not, the T-33 sat on the ground broke; the pilots didn't seem to mind. On the T-33 in Korean Sabre units, see *History of the 4th Fighter-Interceptor Wing, Jul 1951*, 35–36; *History of the 16th Fighter Interceptor Squadron, Mar 1952*, 5; *History of the 16th Fighter Interceptor Squadron, Apr 1952*, 5; Risner, Oral History Interview, 43. On the introduction of instrument flying during the interwar years and its effect on the identity of the pilot, see Jeon, "Technologies of the Operator," chap. 1; Conway, *Blind Landings*.

point that they would subordinate all human intuition and sensory stimuli to their indications. Despite what the E-4 manual suggested, the fire control systems of the day had not yet earned a comparable level of pilot trust.[31]

However, even if the interceptor crews in the F-94, F-86D, or F-89 had followed their fire control system's direction, their rocket weapons remained suboptimal. The rockets had a range of nearly 4,500 feet, but they were still subject to many of the trajectory perturbations that made the original gunnery problem so challenging. And while the rockets also included a proximity fuse, destruction of the target remained far from certain. The rockets' limitations became all too clear on August 16, 1956, when a pair of F-89D Scorpions, each outfitted with the E-6 fire control system and 104 rockets, tried to shoot down a wayward Navy F6F Hellcat target drone that had veered off course toward downtown Los Angeles, California. The Scorpions fired all 208 of their rockets on three firing passes and they missed the pilotless plane every time. The drone eventually ran out of fuel and crashed into a remote field east of Palmdale. The flurry of rockets, however, started "three good-sized fires and numerous smaller blazes," sent shrapnel through one woman's front window, past her 6-year old son and into her panty cupboard, and blew up the pavement in front of a car, leaving the vehicle riddled with holes. Fortunately all survived and the comical incident later became known as the "Battle of Palmdale."[32]

The Air Force's family of Falcon air-to-air guided missiles theoretically promised better results and no more embarrassing gaffes over the California desert. Hughes produced several variants of the Falcon missile, but there were two primary versions, a radar-guided missile and an IR-guided missile (figure 4.4).[33] Both were approximately the same size (6½

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[31] For example, during an evaluation of the F-94 equipped with an E-5 fire control system, an offshoot of the F-86D's E-4, the two-person crews successfully completed only twelve of ninety-four intercepts because they were worried that their fire control system would cause them to collide with the target. *F-94C Squadron Operational Suitability Test*, 194–98.

[32] "208 Rockets Fired at Runaway Plane"; Merlin, "Battle of Palmdale"; Westrum, *Sidewinder*, 30. Still in use in 1961, the effectiveness of the unguided rockets remained a crapshoot. Westrum quotes one Marine Corps pilot: "The plan was to fire a salvo of four 19-shot pods on a 110-degree lead-collision course, with a firing range of 1,500 feet. Whether or not we would have hit anything on a regular basis is a matter for conjecture, but I think not."

[33] A nuclear-tipped version of the Falcon was also developed that had a slightly different missile-body shape than the conventional Falcons. Hughes's involvement in the Falcon can be traced back to the Tiamet and Project MX-570, but specific development of the Falcon stemmed from Project MX-904. For a while, the Falcon was known as XAAM-A-2 (XAAM-A-1 was Ryan's Firebird missile). As the missile entered early testing, it was designated the F-98 to signify its role as an unmanned aerial interceptor. However, that naming practice was discontinued in August 1955 and the Falcon thereafter assumed the standardized GAR (Guided

feet long), shape (fixed canards with delta-finned control surfaces at the tail), and weight (about 135 pounds), designed such so that they could be carried in the internal weapons bays of the Air Force's future high-speed "1954 Interceptor" aircraft. However, after accounting for the necessary rocket propellant and guidance sections, the smallish design left little space in the missile body for the warhead and no room for a proximity fuse. Hence, for all the Falcons, the fuse was attached to the missile's rear fins, which had to actually contact the enemy target to detonate the diminutive 2.7 pounds (in later versions, five pounds) of explosives in the missile's warhead. But, with the missile enjoying the advantage of guidance throughout its trajectory, and with the target assumed to be a large Soviet bomber with plenty of surface area, the design tradeoffs were deemed acceptable.[34]

Figure 4.4. Hughes Falcon Missiles. IR-guided GAR 2 (left) and radar-guided GAR-1D (right). (Source: USAF and O'Connor, *Arming America's Interceptors*)

Development of the radar-guided Falcon preceded that of the IR-guided version, and the resulting GAR-1 Falcon entered testing in mid-1951. Touted as having "electronic 'eyes' and 'brains,'" the missile in reality used semi-active radar homing (SARH) to find its prey. In this guidance scheme, the interceptor aircraft used its radar to illuminate the target aircraft. Then, once the missile was launched, a small radar antenna in the nose of the missile sensed the radar energy reflected off the target, measured the relative change in line-of-sight between the missile body and the radar reflections, and then steered its control fins to zero-out any relative changes, thereby effecting a collision intercept. To provide the necessary target illumination, the interceptor aircraft needed to stay pointed near the target and locked on throughout the missile time of flight. Hence, unlike the earlier gun and unguided rocket

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Air Rocket) label. Later in 1963, McNamara implemented a policy that eliminated the GAR designation in favor of AIM (Air Intercept Missile). O'Connor, *Arming America's Interceptors*; Wildenberg, "Visionary Ahead of His Time," 8. On the nuclear version of the Falcon, see: McMullen, *History of Air Defense Weapons*, 158, 290–96; Schaffel, *Emerging Shield*, 234.

[34] O'Connor, *Arming America's Interceptors*; Westrum, *Sidewinder*, 28; Luke, *Evaluation Report on GAR-1*, 1–2.

armament, the new missiles demanded flawless performance of the pilot, his radar, and his weapon from before the trigger squeeze through target impact. Any hiccups in the interceptor radar's performance, any aggressive maneuvering by the interceptor or the target, or any faults lurking within the missile itself would cause the missile to miss the target.[35]

With the missile alone stuffed with seventy-two finicky vacuum tubes, and the interceptor's radar and fire control system relying on countless more, the system's technical performance was often found lacking. Persistent design problems resulted in numerous production delays. The first GAR-1 Falcon-equipped squadron of F-89H Scorpion aircraft was not declared operational until March 1956, almost two years after the originally scheduled delivery date.[36] Hughes attempted to correct some of the missile's deficiencies in later variants, notably the GAR-1D, which was fielded in 1956 (about the same time the GAR-1 finally became operational), and the later GAR-3, released in 1958. The engineers also worked to improve the missile's performance. For example, the updated GAR-3, the *New York Times* boasted, had "a longer, higher, and deadlier reach than that of any other air-to-air missile," allowing it to "climb far beyond the altitude capabilities of the interceptor and destroy an enemy H-bomber in any kind of weather." Nevertheless, reliability problems persisted.[37]

Hughes's heat-seeking variant of the Falcon, initially designated the GAR-1B but later changed to the GAR-2, suffered from an equally tumultuous development process. Because it relied solely on the heat plume emanating from the target's engine for guidance information, the IR-guided Falcon was in principle simpler than its radar-guided sibling. It was, from its initiation in November 1951, intended to complement and not supplant the radar-guided GAR-1. One 1956 Air Force evaluation report identified the advantages of the heat-seeking missile: the "GAR-1B can be used at lower levels (no ground clutter); against multiple targets (it will select a target); and it has greater accuracy since the missile homes on a point source of heat rather than seeing the entire target. Additional advantages are that it is

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[35] Luke, *Evaluation Report on GAR-1*, 1–2; O'Connor, *Arming America's Interceptors*; "Hughes Falcon."

[36] Westrum, *Sidewinder*, 28; McMullen, *History of Air Defense Weapons*, 157, 277.

[37] "New Missile Ready"; McMullen, *History of Air Defense Weapons*, 278–80, 284; Luke, *Evaluation Report on GAR-1*, 1–2, 8–12; Bauman, *Test Report on GAR-1*, 5. One October 1956 report noted that "out of 48 missiles launched from 1 January 1956 until 1 September 1956, only seven intercepted their target." Another report concluded, "The probability of hit for each missile is 0.25 giving a 0.578 probability of hit for a salvo of three missiles." The follow-on GAR-3 also raised the acceptable aircraft airspeed to launch the missile from Mach 1.3, based on the F-102, to Mach 2.0, based on the Air Force's faster F-106.

a passive seeker, it is immune to electronic countermeasures, and it can be launched with less specialized fire control equipment."[38] But, because the Falcon's small IR-detector, which was mounted under a glass dome in the nose of the missile, needed to be close enough and in a position where it could detect the target's exhaust, the missile had a much shorter range and a more restricted firing envelope than the radar-guided Falcon. For the GAR-2, that translated into attacks of less than a mile and only when launched from within a small thirty-degree cone extending from the target's tail. Restricted firing envelopes like this would plague IR-missiles for decades.[39]

Moreover, there were challenges getting the Falcon's IR-guidance system to work properly outside of the lab. Atmospheric conditions, especially sun-lit clouds and haze, tended to confuse the IR-tracker, causing the missile to careen off course. After a series of dismal test performances in 1959, the engineers at Hughes finally developed an improved IR-guidance unit that used a filter to better distinguish the target's heat signature from that of shorter-wavelength IR-energy in the atmosphere. Later improvements to the GAR-2 eventually culminated in the GAR-4 and -4A, fielded near the turn of the decade.[40]

The new Hughes missiles also required new electronic devices that could effectively link the aircraft's radar, the pilot, and the missile together to form a coherent fire control system. The first Falcon-compatible system was the E-9, developed for use in the F-89H. The engineers at Hughes took advantage of the Scorpion's two crewmembers when they designed the E-9, choosing to saddle the rear occupant with the responsibility for working the radar and the fire control system. They left the front seater alone to concentrate on flying the aircraft. However, with their Falcon missiles originally designed and still destined for use in the single-seat "1954 Interceptor," Hughes needed to develop a more automated system

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[38] Luke, *Evaluation Report on GAR-1*, 2. The evaluation report also reflected the Air Force's dominant vision of air combat against fleets of invading Soviet bombers. Curiously absent from the assumed advantage that the infrared missile "will select a target" was the criteria that the missile actually guide toward the target that it was fired against; apparently any target would do, and there would supposedly be plenty of them in the sky. *Ground clutter* occurs anytime the radar is pointed below the horizon and radar energy reflected off the ground masks the target return; see Stimson, *Introduction to Airborne Radar*, chap. 22.

[39] McMullen, *History of Air Defense Weapons*, 280; O'Connor, *Arming America's Interceptors*.McMullen, *Air Defense Weapons*, 280.

[40] McMullen, *History of Air Defense Weapons*, 283–84; O'Connor, *Arming America's Interceptors*. Carrying the heat-seeking missiles internally in the Air Force's high-speed interceptors further complicated the practical development of the missile because the seeker was unable to detect the target until after it had been launched.

like that in the F-86D that would allow a single pilot to seamlessly fly the aircraft, work the radar, and launch the missiles.[41]

The "1954 Interceptor," so named for the year it was expected to become operational, however, proved overly ambitious. Design issues and production delays almost grounded the project on several occasions. The first aircraft didn't emerge until April 1956, and then only in an interim form as the F-102 Dagger Dart. It wasn't until May 1959 that the ultimate ambition of the "1954 Interceptor" was realized in the F-106 Delta Dart.[42]

The fire control system for the "1954 Interceptor" was nearly as ambitious as the aircraft. Hughes began work on the MX-1179 fire control system in mid-August 1950. The system was to be highly integrated, capable of controlling the aircraft's radar and communication and navigation systems. It would even interface with the aircraft's autopilot. During an intercept, the pilot would essentially relinquish control of the aircraft to the MX-1179 immediately after takeoff. The MX-1179 would then use the aircraft's autopilot to fly an optimum intercept against a specified target that was passed to it via a computer datalink directly from a SAGE command center. At the appropriate range, the system would automatically activate the radar, lock the prescribed target, and fire the missiles. After the target was destroyed, the MX-1179 would fly the interceptor back to its base and execute an automatic ground-controlled approach to landing. Throughout the mission, the pilot "merely" needed "to maintain surveillance over the maze of gadgetry which surrounded him." However, as one report noted, that would still require a "highly capable" individual.[43]

Like most components of the new interceptor, though, the MX-1179 fell behind schedule and an interim solution was devised for use in the compromise aircraft that became the F-102. Nonetheless, Hughes's resulting MG-10 system still achieved a high level of sophistication and semi-automation. Unlike with the MX-1179, which intended to use the pilot only as "an equipment monitor and safety factor," the MG-10 in the F-102 needed its pilot to follow the displayed steering commands and fly the aircraft along the commanded intercept course. But from then on, the MG-3 radar (part of the MG-10 system) would, like

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[41] Long, *USAF Fighter Aircraft Fire Control Systems*; McVeigh and Perry, *Development of the F-102*; O'Connor, *Arming America's Interceptors*. Gabreski, already worried about the "complexity" of the F-86D and its E-4, was dumbfounded that the E-9 planned to use "twice the number of [vacuum] tubes and black boxes as does the E-4." Gabreski, "F-86D Program Deficiencies."

[42] Knaack, *Encyclopedia of US Air Force Aircraft*, 1:158–73, 206–21; McVeigh and Perry, *Development of the F-102*.

[43] McVeigh and Perry, *Development of the F-102*, 88–89, 111.

the MX-1179, automatically lock the appropriate target and fire the missiles at the proper time.[44]

Despite the rapid pace of development, most fighter pilots in TAC remained blissfully unaware of the new Falcon missiles and advanced fire control systems like the MG-10. Those were the tools of the bright-orange-flightsuit-wearing *interceptor* pilots of Air Defense Command (ADC), not the olive-drab-flightsuit-wearing *fighter* pilots of TAC. At the time, the distinction made sense. Interceptor pilots were trained to shoot down menacing enemy bombers approaching the United States, and their guided-missile ordnance and their command and control systems were optimized for that particular type of target. Fighter pilots, on the other hand, were trained to secure air superiority over enemy territory by either destroying enemy fighter aircraft in the air or bombing them on the ground.[45]

The fighter pilots' professional journal, *Fighter Weapons Newsletter*, reflected TAC's near-total ambivalence to the changes taking place in ADC in the latter half of the 1950s. For example, as the F-86D pilots in ADC were learning in 1955 how to use their E-4s to execute rocket attacks according to "thunderbolt geometry"—attacking at high speed from a ninety-degree angle—the non-interceptor-Sabre pilots in TAC were reading Blesse's "No Guts, No Glory" and learning techniques to achieve an optimum close-range, low-angle gunshot. When Falcon missiles started appearing on the wingtip pods of the service's F-89H Scorpions in 1957, fighter pilots in TAC were concentrating on learning how to use their A-4 gunsights in their F-100s to execute supersonic gun attacks.[46] Except for one very technical guest article on the "Application of Infrared Radiation" published in November 1956, there was virtually no discussion in the journal's pages for the half-decade post-Korea on the potential of adopting or adapting ADC's guided missiles or its advanced fire control systems for use in TAC fighters.[47]

The journal did, however, reflect the fighter pilots' growing appreciation for the increasingly technical aspects of their aircraft and air combat. For example, in mid-1956,

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[44] Ibid., 81–83; Umstead, Oral History Interview, 27–28; O'Connor, *Arming America's Interceptors*.

[45] McCarthy, *Phantom Reflections*, 8; Andrews, "To Fly and Fight," 47–48.

[46] Miller, "Thunderbolt Geometry"; Blesse, "No Guts, No Glory"; Whitehead, "Supersonic Air-to-Air Gunnery"; Austin, Oral History Interview, 137–38.

[47] Kutzscher, "Application of Infrared Radiation." The article made no mention of IR-guided missiles, only that "infrared techniques may be used in search equipment, in detection and tracking systems and also in warning devices."

Lieutenant Bruno Giordano, the pilot who years earlier had been frustrated flying with Jabara in Korea, devoted a full 3½ pages detailing how to check proper operation of the A-4 on the ground before flight. A few years later, readers were treated to a lengthy ten-page treatise on the A-4 and APG-30 (MA-3) system in the F-100, complete with mathematical equations. Captain John Boyd's attempt at mathematically describing the perfect "pursuit curve attack" also graced the pages of *Fighter Weapons Newsletter.*[48]

TAC fighter pilots finally took notice of the evolving weaponry in ADC in early 1958 when they began testing an IR-guided missile to augment the cannon armament on their F-100D Super Sabres.[49] Since the Air Force's heat-seeking Falcons were still mired in developmental delays, the Air Force elected to use the Navy's new Sidewinder IR-guided missile, which the Air Force labeled the GAR-8 (the Sidewinder will be discussed in more detail in the next subsection). The new missile elicited an immediate, enthusiastic response from the first F-100 test pilots:

> We feel that GAR-8 (Sidewinder) is just the beginning of a whole new family of Fighter Weapons which will greatly increase our offensive potential. Don't misunderstand us, we do not advocate removing the guns nor do we intend to stop gunnery training. We feel there will be a definite need for air-to-air gunnery training even after the missile has become our primary weapon. It is always possible to find yourself in a position where you are unable to fire the missile, and must make a gunnery attack....
>
> [But] the elusive MiG flying 10,000 to 15,000 feet above us in Korea would be real meat for GAR-8. We might have to revise our standards for qualifying as an ACE in future conflicts.[50]

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[48] Giordano, "A-4 Sight Check"; Tucker, "Fire Control"; Boyd, "Fire Control Problems." On the shift in the journal's contents, see Giraudo, Oral History Interview, 141–42. Boyd's article earned a special notice from the editors: "It is suggested that this article be given more than just a cursory reading." See also the pair of mid-1956 articles on computing gunsights and the intricacies of the APG-30 radar: Jenkins, "Some Notes"; Wells, "Tips and Info for AN/APG-30 Radar." Of course, not all pilots immediately took to the new technical approach; see, for example Cook, *Once a Fighter Pilot*, 34.

[49] Knaack, *Encyclopedia of US Air Force Aircraft*, 1:123. The initial decision to explore use of IR-guided missiles on the F-100 occurred in late 1955. In September 1956, the Sidewinder was selected over the GAR-1B Falcon to provide the supplemental armament for the F-100D, but the new capability did not appear until after the 184th F-100D rolled off the assembly line.

[50] Thor, "GAR-8," 30. The initial article was followed by a more detailed one eighteen-months later; see Giordano, "F-100D GAR-8 Tactics." One F-100 pilot explained that "firing my first Sidewinder missile ... was a great experience, but there was really nothing to it once you learned what to do... You just pressed that trigger and away it went and 'blam.'" Knight, Oral History Interview, 119.

The pilots' assessment would prove prescient three years later when the Air Force decided to acquire the Navy's exclusively missile-armed F4H Phantom II fighter.

The Phantom Appears

In 1961, the Air Force was desperate to update its "obsolescent" tactical fighter and reconnaissance force with new aircraft that boasted better speed, altitude, range, and all-weather attack capabilities. The design of its F-100 Super Sabres was a decade old. The Air Force had newer F-105 Thunderchiefs, but those aircraft were originally built to replace the service's F-84 of Korean War-vintage. The Thud's design clearly emphasized the *bomber* portion of the fighter-bomber mission. TAC had begun work in 1958 outlining requirements for a Mach 2, 60,000-foot, all-weather fighter, but that aircraft had been transformed into the joint Air Force-Navy TFX (Tactical Fighter Experimental) and was now languishing in development by joint committee.[51]

Coincidentally, the Navy had just begun taking deliveries of its new F4H Phantom II, produced by McDonnell Aircraft Corporation. Aware of the Air Force's dilemma, executives at McDonnell initiated an intense marketing campaign that targeted Air Force senior leaders and the budget-minded "whiz kids" in the Pentagon. The lobbying ultimately proved successful when in December 1961, the Air Force elected to procure virtually unmodified the Navy's F4H as an "interim fighter" that would sustain TAC until the arrival of the TFX. The Air Force planned to rename the Navy's F4H the F-110 Spectre, but the F-110 designation was abandoned following an August 3, 1962, decree by Secretary of Defense Robert McNamara that required the services to standardize their aircraft nomenclature. Hence, the Navy's preproduction F4Hs became F-4As, its production model F4Hs became F-4Bs, and the Air Force's F-110 became the F-4C; all versions retained the "Phantom II" moniker.[52]

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[51] *F-4C System Package Program*, August 31, 1962, 5–2; *F-4C System Package Program*, September 1963, 12–17; Knaack, *Encyclopedia of US Air Force Aircraft*; *History of the Tactical Air Command, Jul - Dec 1961*, 1:17, 202–12; *History of the Tactical Air Command, Jan - Jun 1963*, 1:275–280; Gillespie, "Mission Emphasis," chap. 3. The F-101 Voodoo was likewise based on a 1951 design and never found an enthusiastic following in TAC except as a tactical reconnaissance platform. The F-102 and later F-106 were all specially designed ADC interceptors, not TAC fighters. The Kennedy administration's emphasis on "flexible response" and "limited," as opposed to "total" or "nuclear," war was also a commonly cited justification for upgrading the quality and quantity of TAC's fighter force.

[52] *History of the Tactical Air Command, Jul - Dec 1961*, 1:194–202; *History of the Tactical Air Command, Jul - Dec 1962*, 1:242–44; *F-4C System Package Program*, September 1963, 12–8, 12–10; Gardiner, "Effectiveness of F-4H";

The F4H was designed in the immediate wake of the Korean War to serve as the US Navy's newest ground-attack aircraft, or its newest reconnaissance aircraft, or electronic warfare aircraft, or even air-to-air interceptor. McDonnell engineers planned to achieve this remarkable versatility by pairing a standard aircraft fuselage and wing section, over-powered by two massive J-79 afterburning engines, with interchangeable nose assemblies stuffed with electronic equipment optimized for each unique mission. Responding to the Navy's initial wishes, McDonnell expected the ground-attack configuration to be primary, and they therefore planned to arm their aircraft with four 20-mm cannons or fifty-six unguided rockets. However, in mid-1955, the Navy balked at the radical design and instead dictated that a single nose assembly be permanently affixed to the aircraft fuselage. A few months later, the Navy announced that it wanted an aircraft optimized not for ground-attack but for intercepting enemy aircraft and defending the carrier fleet.[53] Following the announced shift in the primary mission, engineers quickly reappraised their aircraft's proposed armament.

Like the Air Force, the Navy had begun experimenting with guided air-to-air missiles immediately following World War II. In 1947, the Navy contracted with Sperry Gyroscope to build the Sparrow missile. But whereas the Air Force's radar-guided Falcons used SARH guidance, the Navy's first Sparrows, which entered the fleet in mid-1954, were beam-riding missiles, a simpler design but one that also proved to be more aerodynamically inefficient when attacking maneuvering targets.[54] Douglas Aircraft Company hoped to rectify the issue

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Knaack, *Encyclopedia of US Air Force Aircraft*, 1:333; Bugos, *Engineering the F-4*, 105–6, 116–20. TAC's official history notes that a handful of "Air Force senior officers" had an opportunity to fly the F4H in 1960, after which they issued "a favorable report." Later analysis conducted by TAC concluded: "The F4H-1 was an exceptionally good aircraft with no poor characteristics; ... it was superior in the tactical mission to any aircraft currently in the inventory; the two seats and two engines decreased the accident potential; and the two seats would mean saving a wing organization normally used for single seat training." Additional TAC analysis concluded that the F4H would be "more than 100 times" more effective per sortie during a close air support mission than the A-4, another aircraft then-under consideration. Bugos claimed that the performance of the Navy's Phantom in a fly-off against the Air Force's F-105 in early 1961 sealed the deal.

Several authors contend that the F-4's ability to be adapted to drop tactical nuclear bombs was a major selling point for TAC officers looking to establish themselves in an Air Force hierarchy dominated by the bomber-generals of SAC. On the "SAC-timization" of TAC, see Creech, Oral History Interview, 42–45; Hildreth, Oral History Interview, 54; Welch, Oral History Interview, 71; Crane, *American Airpower Strategy in Korea*, 172; Ziemke, "In the Shadow of the Giant"; Hannah, *Striving for Air Superiority*.

[53] Boyne, *Phantom in Combat*, 10; Bugos, *Engineering the F-4*, chap. 1.

[54] Bugos, *Engineering the F-4*, 76–79; Westrum, *Sidewinder*, 44. The beam-riding Sparrow had its antenna located in the tail of the missile. When the attacking aircraft locked the target with its radar and fired a Sparrow, the missile maneuvered itself to remain in the radar beam that went from the attacker to the target. Consequently, if the target or the attacker turned while the missile was in-flight, the missile needed to adjust its position to

with an improved Sparrow II that would fly directly and autonomously to the target, guided by an active radar seeker mounted in its nose. To ensure compatibility, Douglas planned to retain the same size and shape of Sperry's original Sparrow design. Never intended to be carried internally, the Sparrow measured twelve-feet in length, almost twice that of the Air Force's Falcon. It capitalized on its size to pack a considerably larger wallop than the Falcon, too; the Sparrow sported a sixty-five-pound warhead along with a proximity fuse to detonate it. However, despite the Sparrow's large size, Douglas engineers could not find a radar that was compact enough to fit inside the missile's nose; only K-band radars came that small, but they couldn't reliably see through cloud moisture. The Sparrow II never reached full-scale production.[55] Raytheon threw its hat into the ring in mid-1951 when it began working on a new Sparrow III design. Like Douglas, Raytheon also retained the original size and shape of the Sparrow, but it chose to adopt the SARH guidance scheme used on the Air Force's Falcons. The Sparrow III performed reasonably well during testing, and in 1957, Sperry's Sparrow I was discontinued in favor of the Sparrow III. The Navy set sail with the Sparrow III in July 1958 (figure 4.5).[56]

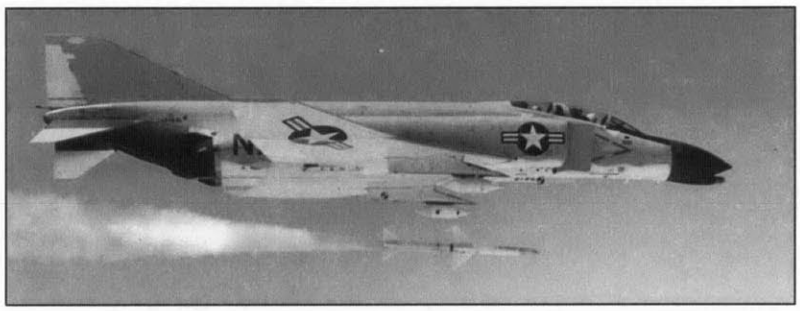

Figure 4.5. Navy F-4B Launching a Sparrow III.
(Source: Naval Aviation Museum, Robert L. Lawson Collection)

The competition between the three different versions of the Sparrow occurred while the engineers at McDonnell and their Navy counterparts were wrestling over how best to arm their new F4H fighter. In August 1955, following a successful round of missile testing, Captain Frank Timmes, the Navy officer in charge of the F4H project, decided to adopt Douglas's Sparrow II for use on the Phantom II. Echoing the Air Force's rationale, Navy officials reasoned that the new guided missiles would ultimately provide them with more offensive firepower and greater flexibility. As Glenn Bugos explained, with missiles,

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remain in the straight-line radar beam between the attacker and the target aircraft, which caused the Sparrow to expend its limited thrust flying a curved flight path to the target rather than a straight, cut-off intercept.

[55] Bugos, *Engineering the F-4*, 79–80; Westrum, *Sidewinder*, 43–44, 131–32.

[56] Bugos, *Engineering the F-4*, 80–81; Westrum, *Sidewinder*, 44–46, 132.

engineers "could decide which tasks—how much guidance or speed—should be built into the missile and which built into the aircraft, and how these tasks should be shifted between the aircraft and the missile as the technologies changed."[57]

The decision to use the Sparrow on the Phantom required a new, integrated fire control system be developed, and the Navy contracted with Raytheon for its Aero 1A Airborne Missile Control System (AMCS). The heart of the AMCS was the APA-128, which provided the necessary interfaces and controls that linked the crew, the radar, and the weapons with one another. The Phantom's radar also needed to be adapted to the new armament. Initially designed to use a twenty-four-inch radar antenna, the Phantom's dimensions were tweaked to accommodate a larger and more powerful thirty-two-inch antenna as part of the Westinghouse APQ-72 radar.[58]

The Navy at the time was also working on its own IR-guided missiles. Similar in concept to the already-discussed heat-seeking Falcons for the Air Force, the Navy's Sidewinder missile used an IR-detector mounted under a glass dome in the nose of the missile to detect the target's hot jet exhaust and then steer the missile body toward the target. And, like the Falcon, the Sidewinder had a correspondingly limited effective range and a restricted firing envelope. But, at 9½-feet long, the Sidewinder had room for a larger twenty-five-pound warhead and a proximity fuse to detonate it, which dramatically enhanced its lethality. During a set of joint missile tests at Holloman AFB in June 1955, the Navy's Sidewinders posted a perfect score. Observing the tests was the commander of the Air Force's Missile Development Center, General Leighton Davis, the same MIT graduate who had once spurred the Air Force to develop the A-1 gunsight. Suitably impressed with the Sidewinder's performance, he immediately pledged Air Force support for the Navy missile. The first Sidewinders (AIM-9As) became operational in the Navy in July 1956 (figure 4.6). A year later, an improved version made its way into the Navy as the AIM-9B and the Air Force as the GAR-8.[59]

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[57] Bugos, *Engineering the F-4*, 3, 27–28.

[58] Ibid., 27–28, 82–89. Bugos notes that a thirty-two-inch radome had never been built for a fighter, and the search for a radar-transparent material that could withstand the aerodynamic forces at the pointy-end of a Mach 2 fighter proved difficult. The Brunswick Company, famous for their bowling balls, eventually developed a viable solution. The Raytheon Aero 1A included the package of the APQ-72, APA-128, and the AAA-4, an auxiliary, nose-mounted IR-tracking system.

[59] Ibid., 89–90; Westrum, *Sidewinder*, 24–25, 129–32, 136–44, 170–75, 205–6; Michel, *Clashes*, 13. Whereas the other guided missiles procured by the Air Force and Navy were designed by industry on contract, the

By June 1956, the Navy had dropped the Sparrow II in favor of Raytheon's improved Sparrow III and designated the radar-guided missile the primary armament system for the F4H. It had also decided to incorporate the Sidewinder missile into the Phantom's emerging fire-control system. A subsequent decision in April 1957 to purge the original 20-mm cannons from the F4H's design, reducing the aircraft's weight and freeing up space for the electronic components of the advanced fire control system, completed the transition from the "archaic" aircraft guns of yesteryear to the futuristic guided missiles of tomorrow.[60]

Figure 4.6. Navy F9F-8 Carrying Sidewinders.
(Source: Naval Aviation Museum, Robert L. Lawson Collection)

While the engineers at McDonnell wrangled over the Phantom's armament, they became increasingly convinced that only a two-person crew could manage the sophisticated technologies they planned to pack into the Phantom. Initially, the idea of a two-person fighter plane encountered stiff resistance among naval aviators. They, like their Air Force brethren, had no desire to relinquish their single-seat autonomy, and they insisted that they could adequately manage any complex radar or armament system then-envisioned. But, as the F4H design slowly morphed into an all-weather interceptor solely dependent upon guided missiles, the Navy's position began to soften. Bugos summarized McDonnell's argument: "A second crew member was mandatory in some roles … but superfluous in none."[61]

Sidewinder missile was designed in-house at the Naval Weapons Laboratory at China Lake, California, under the supervision of William McLean. The resulting missile performed well, often besting the Sparrow by a factor of two in missile tests, and at only one-half the cost per missile. The Sidewinder also routinely showed-up the Air Force's IR-guided Falcon. McLean's simple design would ultimately be stolen by the Soviets, appearing as an AA-2 Atoll.

[60] Bugos, *Engineering the F-4*, 27–28, 82–89; Burns, Oral History Interview, June 5, 1984, 171. Burns suggested that the Navy engineers removed the Phantom's gun to better streamline the aircraft so that it could achieve its extreme airspeeds more efficiently. Reflective of the common attitude within the Pentagon, McNamara reportedly quipped, "In the context of modern air warfare, the idea of a fighter being equipped with a gun is as archaic as warfare with bow and arrow." Quoted in Michel, *Clashes*, 16.

[61] Bugos, *Engineering the F-4*, 26–27, 97–98, 106–7.

In April 1957, the same month the gun was finally stripped from the aircraft design, the Navy finally acceded and the Phantom permanently became a two-seater. Reflecting the conventional distribution of tasks, the back seater would be responsible for operating the radar while the front seater focused on flying the plane. The Navy also decided that it would create a new Naval Flight Officer, specially trained in radar theory and radar operation, to man the Phantom's back seat. Because the new officer, colloquially referred to as a RIO (radar intercept officer), was not going to be a trained pilot, the Navy decided not to install any flight controls in the rear cockpit of the Phantom II. After a series of F4H flight trials in September 1958, one Navy official declared triumphantly, "The single seat fighter era is dead, and no more should be initiated." Another agreed, proclaiming, "The greater effectiveness of the two seat airplane in adverse conditions is decisive." By October 1961, Navy Phantoms were flying off carrier decks in the Mediterranean and the Western Pacific, manned by a pilot in the front seat and a RIO in the rear seat, armed with four radar-guided Sparrows, four heat-seeking Sidewinders, and no gun.[62]

When Air Force officials elected to procure the Navy's Phantom as a "multi-purpose fighter bomber" in late 1961, it left the Navy's design virtually unchanged. The service's decision is often attributed to McNamara's demand for defense commonality and efficiency, but the Air Force's actions were more a reflection of the urgency it attached to getting its new fighter into the air as rapidly as possible. For example, in an internal memo dated November 7, 1961, Air Force officials disclosed the "sufficiently firm" possibility that their service would acquire more than 500 Navy F4Hs. The memo also noted that initial consultations with McDonnell representatives had identified only five changes necessary to adapt the Navy's Phantom for Air Force use. Some of the required fixes included: replacing the Navy's probe-and-drogue in-flight refueling system with one compatible with the Air Force's boom-equipped tankers; equipping the Air Force version with a self-contained starting capability; and incorporating provisions for the aircrews to employ the Air Force's GAM-83 Bullpup, radio-guided, air-to-surface missile.[63]

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[62] Ibid., 26–27, 97–98, 105–7.

[63] Holsapple to AFSC and AFLC, "F-4H"; *History of the Tactical Air Command, Jul - Dec 1961*, 1:197. The November 7, 1961, memo followed a two-day conference held 2-3 November. Of note, McNamara's memo announcing the termination of the F-105 and directing the Air Force to acquire the Navy's F-4 was dated February 17, 1962 (included in *F-4C System Package Program*, September 1963, 12–8.). After launching a Bullpup

Over the next few months, the list of changes grew. Many of the new additions reflected the Air Force's attempts to bolster the Phantom's air-to-ground capability. For example, a self-contained inertial navigation system (INS), a radar altimeter, and a new APQ-100 radar that could better accommodate ground mapping (and an accompanying APA-157 radar set, functionally similar to the earlier APA-128) were all added to the Air Force's version of the F-4. But overall, most elements of the original Navy design remained.[64]

From the outset, however, the Air Force was adamant that its version of the Phantom include a full set of flight controls and instrumentation for the rear cockpit. The November 7, 1961, memo made clear that the service wanted the ability to "fly and land" its Phantoms from the back seat, but it did not specify who the service planned to put in the fighter's rear cockpit. That uncertainty was removed when the Air Force published its Specific Operational Requirement (SOR-200) for the F-4C on August 29, 1962; there would be no un-winged RIOs sitting in the Air Force's Phantom. The Air Force planned to put two fully trained pilots in both seats of its newest fighter. While the implementation of the decision suggests that the service viewed the Phantom's back seat as an opportunity to further groom its fledgling fighter pilots, others have suggested that the policy was simply an attempt to increase the rolls of Air Force pilots.[65]

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missile, the pilot steered the missile to the target using a control stick located in the aircraft cockpit; the missile used two small flares at its tail to help the pilot keep sight of the missile while it was in-flight.

[64] Holsapple to AFSC and AFLC, "F-4H"; *F-4C System Package Program*, August 31, 1962; *F-4C System Package Program*, September 1963; Donovan to HQ USAF, "Configuration of the F4H"; HQ TAC to ASD, "Proposed System Package for the F4H"; *History of the Tactical Air Command, Jan - Jun 1962*, 1:247–52; *History of the Tactical Air Command, Jul - Dec 1962*, 1:231–45; Bugos, *Engineering the F-4*, 121–23; Burns, Oral History Interview, June 5, 1984, 162–69.

[65] Holsapple to AFSC and AFLC, "F-4H"; Donovan to HQ USAF, "Configuration of the F4H"; Norman to USAF, "F-110 Radar Pilot Training"; *F-4C System Package Program*, August 31, 1962; *F-4C System Package Program*, September 1963, 12–2, 12–20. The original August 29, 1962, SOR-200 is included in the September 1963 revision to the "F-4C System Procurement Package" document. The SOR stated: "The Navy F4H is crewed by a pilot/radar operator combination. The Air Force F-4C will be manned by a crew of two pilots." I have been unable to locate official, documented rationales for the decision; most available information is only anecdotal. Neither ADC's F-89 or F-94 aircraft included provisions or controls for the back seater to fly the plane. Hill suggested that the Air Force used the F-4 rear seat "as a back door way to get authorization for more pilots." Burns similarly noted that he was told the rational for using two pilots in the Phantom was, given the "choice … to either turn up the gain on pilot training or navigator training," it made more sense to increase the number of pilots, especially since "we almost always seem to short of [them] in a crunch period." But Burns also acknowledged that as the Air Force got into "an era of very expensive airplanes, … an argument could be made that by putting the fellow in the back seat of an F-4 … he could get his apprentice training." See: Hill, Oral History Interview, 20–21; Burns, Oral History Interview, June 5, 1984, 215–16; Everest, Oral History Interview, 13–14. The decision to field pilots in both seats of the F-4C demanded a significant increase in Air Force pilot production. Struggling to meet the new quota, officials in ATC toyed with the idea of shortening

Regardless, following a series of flights in the back seat of a Navy F4H in late November 1961, the Air Force determined that the Phantom's rear cockpit required thirty-six "provisions" before it could be deemed capable of supporting full flight operations. These included, among other things: a full suite of flight instruments; engine performance indicators; controls for the landing gear, flaps, and brakes; and obviously a control stick and rudder actuators. While the original Navy F4H included some of these items in the rear cockpit, many would need to be added to support the Air Force's desire for a two-pilot crew.[66]

Shortly thereafter, the Air Force adjusted its expectations. By the time SOR-200 was released, the Air Force had decided that the rear cockpit only required "sufficient" equipment to "land the aircraft safely … *in emergencies.*" With this subtle change, normal actuators for the landing gear and flaps were no longer necessary; a one-time emergency extension capability would suffice. Those working on the rear cockpit design also reasoned that the back seater didn't need the ability to ignite the engines' afterburners. And, while the GIB was provided with most of the requested flight instrumentation, it was cobbled together and not arranged in the commonly approved layout (figure 4.7). One GIB griped at the injustice of having to fly from the back seat using "this little rinky-dink attitude indicator and a little rinky-dink heading indicator" while the front seater got to use his giant, "cosmic" flight instruments.[67]

The Air Force's first YF-4C prototype was delivered on May 27, 1963, sixty-five days ahead of schedule. Six months later, on November 20, 1963, the Air Force's F-4C version of the Navy fighter entered operational service at MacDill AFB, Florida, armed with four Navy

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the pilot training program by ten weeks. See, for example: Briggs to HQ USAF/AFPDC, "Proposed Changes in Pilot Training"; McGehee to ATC (ATXDC), "Flight Indoctrination."

[66] Donovan to HQ USAF, "Configuration of the F4H"; *F-4C System Package Program*, September 1963, 6–36; *History of the Tactical Air Command, Jan - Jun 1962*, 1:233. The Navy version of the Phantom included provisions for a removable, stowable flight control stick, but it could not be used during intercept missions. As Cook noted, "pilots don't like flying when they don't have a set of controls." Cook, *Once a Fighter Pilot*, 85.

[67] *F-4C System Package Program*, August 31, 1962, 6–37–38; *F-4C System Package Program*, September 1963, 6–36–37, 12–20; Cook, *Once a Fighter Pilot*, 90–91; McCarthy, *Phantom Reflections*, 32–33; Anderegg, interview, October 2, 2013; Sokol, interview; Attinello, *Air-to-Air Encounters in Southeast Asia: Account of F-4 and F-8 Events Prior to 1 March 1967*, 197. Emphasis added. Because they were pilots, the GIBs still had to maintain their Air Force pilot currencies, including annual instrument checkrides. Cook remembered one general telling the new Phantom pilots, "With two big engines and two pilots, there will be no excuses for F-4 accidents."

Sparrow III radar-guided missiles, four Navy Sidewinder IR-guided missiles, no gun, and two pilots.[68] Now the pilots in TAC just needed to learn how to operate it.

Figuring Out the F-4C

Years later, Air Force fighter pilots would deride their service's decision to acquire the *Navy*-designed, *two*-seat, *missile-only* F-4. As noted earlier, both the dual-seat configuration of the Phantom and its lack of a gun were anathema to the myth of the fighter pilot, and it stoked the fighter pilots' fears that they were perilously close to becoming mere "missile managers."[69] The pilots' criticisms, however, were levied only with the benefit of hindsight. Even by 1961, many pilots were still haunted by the memory of MiGs overflying them in Korea, and any technological advancements that seemed to reduce the chances of similar, future frustrations were

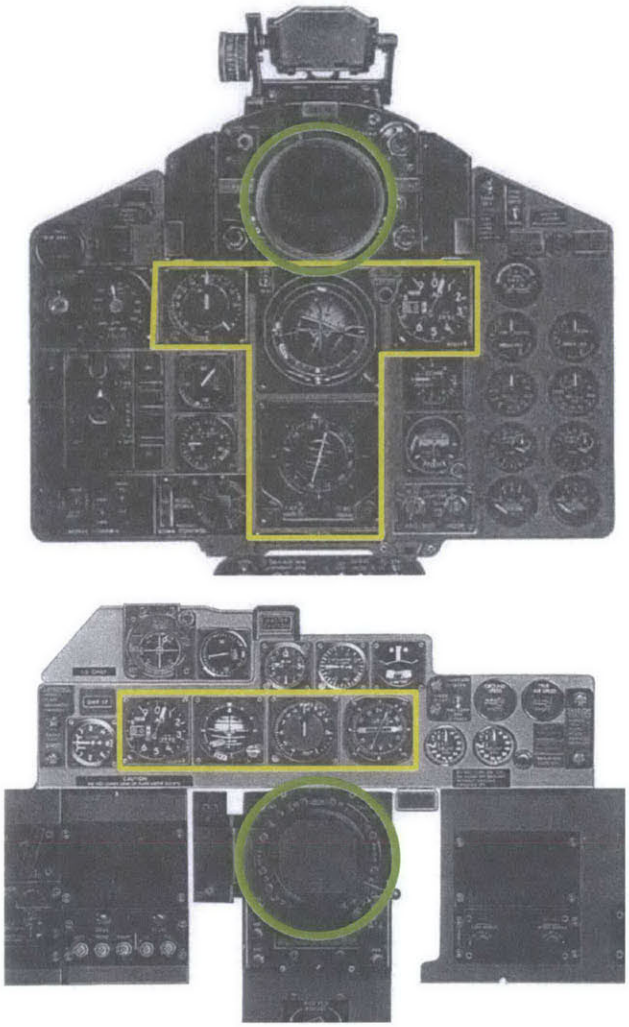

Figure 4.7. F-4C Cockpit Layout.
In the front cockpit (top), the flight instruments were arranged in the common "T" pattern, with the large primary attitude indicator located at top center (airspeed to the left, altimeter to the right, and heading indicator below). A radar display was mounted above the attitude indicator. In the rear cockpit (bottom), the flight instruments were smaller and arranged in a horizontal line (altimeter, attitude, airspeed, and heading, left-to-right). The radar display was mounted on the center pedestal between the knees of the occupant.
(Source: *T.O. 1F-4C-1*, FO-17, FO-19)

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[68] Knaack, *Encyclopedia of US Air Force Aircraft*, 1:266.

[69] Andrews, "To Fly and Fight," 55–56. For a sampling of the revisionist accounts, see: Burns, Oral History Interview, June 5, 1984; Catledge, Oral History Interview; Blesse, Corona Ace Oral History Interview; Blesse, *Check Six*; Cook, *Once a Fighter Pilot*, 208–11. For example, Burns characterized the Pentagon's prevalent attitude at the time as reflecting an opinion that aircraft guns were "anachronisms, throwbacks to earlier, bygone days.... That the day of the gun was gone, and that the day of the maneuvering fighter was gone, and that air combat would consist entirely of a radar detection and acquisition and lock-on, followed by a missile exchange"; those, like himself, that argued to the contrary were "voices in the wilderness." See also Bugos's interpretation of the rationale for removing the F-4's gun in Bugos, *Engineering the F-4*, 28.

greeted with enthusiasm, at least initially.

Hence, the new, beastly looking Phantoms, like the earlier GAR-8s on the F-100Ds, elicited a rhapsodic response from the pilots. The Navy's F-4 had already established several aeronautic records, including maximum straight-away speed and numerous time-to-climb marks, the details of which were featured prominently in McDonnell advertisements. One aviation publication described the Phantom as "one of the hottest machines that fifty-plus years of airplane building" had produced. A June 1962 article in *Fighter Weapons Newsletter* similarly gushed over the Phantom and its "amazingly responsive" engines and its smooth, "comfortable" flight characteristics. Coupled with its "Mach 2 plus max [speed]" and "a deadly fire control system (including outstanding radar detection and lock-on ranges)," one Air Force pilot declared of the new airplane, "I'm sold on the F-110A."[70]

The first Air Force Phantom aircraft commanders were culled from the ranks of the service's top F-100 fighter pilots.[71] Later, whole scores of new aircraft commanders were taught how to fly the F-4 as TAC units began trading in their older aircraft for newer F-4Cs. One of the transitioning pilots was Larry Welch. Welch, born in Oklahoma but raised in Kansas, originally enlisted in his hometown's artillery unit of the Kansas National Guard. Two years later in November 1953, he elected to join the Air Force through the Aviation Cadet program. After earning his commission and his wings, Welch ended up flying F-84s at a variety of locations before converting to the F-4 with the other members of the 366th TFW. Training in the new Phantom was initially conducted at MacDill AFB; the Air Force having recently replaced its borrowed Navy F-4Bs located at the base with its own F-4Cs.[72]

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[70] "Feats of a Phantom"; "F-110"; Allen, "Meet the F-110A," 20–22. Another test pilot reported, "The F-110A is one of the best aircraft I've ever flown"; see *History of the Tactical Air Command, Jan - Jun 1962*, 1:245. Cook boasted that he already "knew all the numbers" when he received his assignment to fly the F-4C: "Zero to 39,000 feet in one minute and seventeen seconds. One thousand, six hundred miles an hour. Two and one-half times the speed of sound." Cook, *Once a Fighter Pilot*, 82.

[71] *History of the Tactical Air Command, Jul - Dec 1962*, 1:182–83. The TAC commander wanted to fill his new Phantoms with "only the most highly qualified personnel," and he consequently asked his F-100 Wing commanders to send him the names of their top ten fighter pilots for reassignment. Among other requirements, candidate pilots needed to possess "a minimum of 1,500 hours total flying time" and "1,000 hours single engine jet time." Of the names forwarded, fourteen were designated as initial cadre in the F-110 while another fifteen were sent to bolster the ranks of F-105 pilots.

[72] *History of the Tactical Air Command, Jan - Jun 1963*, 1:303; *History of the 366th Tactical Fighter Wing, Jan - Jul 1965*, 1:1–2; Welch, Oral History Interview; *History of the 15th Tactical Fighter Wing, Jan - Jun 1964*, 1; *History of the 15th Tactical Fighter Wing, Jul - Dec 1964*, 14–15; *History of the 4453d Combat Crew Training Wing, Jul - Dec 1966*, 1:1–2; *History of the 15th Tactical Fighter Wing, Jan - Jun 1966*, 1:8–9; Scholin, "New Phlyers for the Phantom," 46. The last five F-4Bs on-loan from the Navy were returned on June 3, 1964; *United States Air Force Statistical Digest: Fiscal Year 1964*, xliv. At the height of the war, F-4 training was conducted by the 15th Wing at McDill AFB;

Like all of the new Phantom front seaters, Welch had already proven his mettle flying one of TAC's single-seat fighters. But, even with his experience, it still required more than two months to learn the intricacies of the F-4C, with more than 100 hours spent in ground academics and another thirty hours spent in the air.[73]

Colonel Olds, en route to his assignment as the Wing commander at Ubon, was special, though. His program lasted less than a week. It was still enough time for the World War II veteran flyer to develop an immediate fondness for the F-4. Olds later remarked that he "loved the Phantom. Everything about it felt right. It was light on the controls and quickly responsive to power changes, and it gave me a feeling of eagerness not normal in an object weighing more than 17 tons."[74] Olds also had the opportunity during his abbreviated training program to witness the Phantom's more unruly side—its tendency to suddenly snap out of control and enter a spin if the pilot applied the slightest sideways movement of the control stick at high angles of attack (AOA).[75]

Learning how to fly the F-4 so as to avoid "the adverse yaw demon" was one of the key lessons drummed into the front seaters during their Phantom flight training.[76] The new aircraft commanders also learned other typical piloting tasks, such as how to take-off and land, drop bombs (both conventional and nuclear), and fly air combat maneuvers (ACM), the new term for dogfighting. None of these tasks were radically different from those they

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the 479th at George AFB, California; and the 4531st at Homestead AFB, Florida; only a single stateside wing, the 33d at Florida's Eglin AFB, flew the Phantom in a non-training function.

[73] Meyer, "Phantom Over Tampa Bay"; *History of the 4453d Combat Crew Training Wing, Jul - Dec 1966*, 1:1–5; *Combat Crew Training Course: F-4C*, 1–2; *USAF Replacement Training Course: F-4C*, 2–3; *Format for the Syllabus of Instruction: F-86*, 2–3. Originally in December 1963, ground training and simulator practice for converting fighter pilots was expected to entail a total of 180 hours of instruction. By late 1966, the ground instruction requirement for transitioning pilots (combat crew training) had grown to more than 250 hours. For those pilots destined for the front seat of the Phantom who had not yet accumulated appreciable flight time in another fighter, a separate four-month long RTU (replacement training unit) syllabus was developed in 1966 that included eighty-one hours of flight time and 240 hours of ground instruction. For comparison, the October 1952 training syllabus for new fighter pilots training in the F-86 entailed seventy-eight hours of academic instruction, no simulator time, and eighty hours of flight training.

[74] Olds, *Fighter Pilot*, 249; *History of the 4453d Combat Crew Training Wing, Jul - Dec 1966*, 1:5, 22. Although Olds claims that he completed the course in less than a week, training records indicate that Olds was enrolled in the program from August 18 through September 27. Olds's program was an abbreviated checkout course that was used "to transition commanders and other key personnel in the F-4." Normally, the program included eleven sorties, and it may be the flying portion of Olds's training that was curtailed and completed in less than a week.

[75] Olds, *Fighter Pilot*, 249–51; Allen, "Meet the F-110A," 21. Allen's June 1962 assessment of the F-110, in which he extolled the Phantom's flight characteristics and bragged that the aircraft "exhibits no dishonest characteristics when being yanked, banked and kickin' rudder," proved not entirely accurate.

[76] On adverse yaw in the F-4, see: Stuck, "Aircraft Control"; *F-4 Aircrew Operational Procedures*, 23–24; Leatham, "Adverse Yaw"; Calvert, "Turning the F-4"; Anderegg, *Sierra Hotel*, 12–13; Cook, *Once a Fighter Pilot*, 192–95.

had practiced countless times before in their prior fighters. For example, despite being almost a decade old and written for pilots who flew aircraft armed with guns and not missiles, Blesse's "No Guts, No Glory" was still distributed to the F-4 student pilots as an approved manual on ACM.[77] There was, however, one new task that few of the experienced fighter pilots had practiced before, and it consequently consumed a good chunk of training time, nearly fifty hours of classroom and simulator instruction, almost as much time as that devoted to reviewing the mechanics of the aircraft and its electrical, hydraulic, and fuel systems. The new unfamiliar topic was the Phantom's APQ-100/APA-128 radar and fire control system and, more specifically, how to use them in air combat.[78]

Meanwhile, the future GIBs, usually young officers who had just graduated from pilot training, began their Phantom immersion with an intense, eight-week radar fundamentals course which consisted of over 208-hours of classroom and simulator instruction on radar theory, operation, navigation, and basic intercept geometry. After completing the specialized course, the GIBs then transitioned to the F-4 conversion course that the aircraft commanders were attending and sat through eighteen-more hours of academics on intercept tactics with their front seaters. The program could be mind-numbing for the young lieutenants, but it was extremely important.[79] Flight regulations dictated that it was the sole responsibility of the "pilot" to "operate and monitor the F-4's radar," thereby freeing the "aircraft commander" to "fly the aircraft."[80] The task assignments specified in the regulation were merely a formality, though. Reflecting the common convention, McDonnell engineers had vested all control over the radar functions and operation in the hands of the back seater. Although the aircraft commander had a radar scope prominently mounted

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[77] Anderegg, *Sierra Hotel*, 20–21; *Combat Crew Training Course: F-4C*; *F-4C Air Combat Tactics*, Supplement No. 1. Whereas ACM focused primarily on close-range, visual dogfighting, air combat tactics (ACT) encompassed the entire air-to-air combat environment, from long-range intercepts through ACM.

[78] *Combat Crew Training Course: F-4C*, 2, 6. See also McCarthy, *Phantom Reflections*, 17; *History of the 15th Tactical Fighter Wing, Jan - Jun 1966*, 1:8–16; *History of the 15th Tactical Fighter Wing, Jul - Dec 1966*, 2:9–20.

[79] *Radar Academic Training Course: F-4C*; Meyer, "Phantom Over Tampa Bay"; *F-4C System Package Program*, September 1963, 12–20; Sokol, interview; Anderegg, interview, October 2, 2013. On the initial development of the radar course, see: Krebs to ATC and TAC, "F-110 Radar Pilot Training"; Norman to USAF, "F-110 Radar Pilot Training"; Heflin to TAC, "Radar Pilot Training (APQ-72)"; Feezel to CSAF, "Bench Sets/Component Lab Sets"; Stewart to HQ USAF (AFPTR-F-N), "Requirements for the Radar Pilot Training"; *History of the Air Training Command, Jul - Dec 1962*, 1:115–16; *History of the Air Training Command, Jan - Jun 1963*, 1:119–20. After the decision was made to scrap the F-108, ATC elected to discontinue its RIO training program in November 1963; the course had used F-89Js as training aircraft.

[80] *F-4 Aircrew Operational Procedures*, 29.

directly in front of him (figure 4.6), it was simply a repeater display; he had absolutely no control over the radar. Consequently, the new crews quickly learned that without a properly trained GIB, the radar in the Phantom was useless.

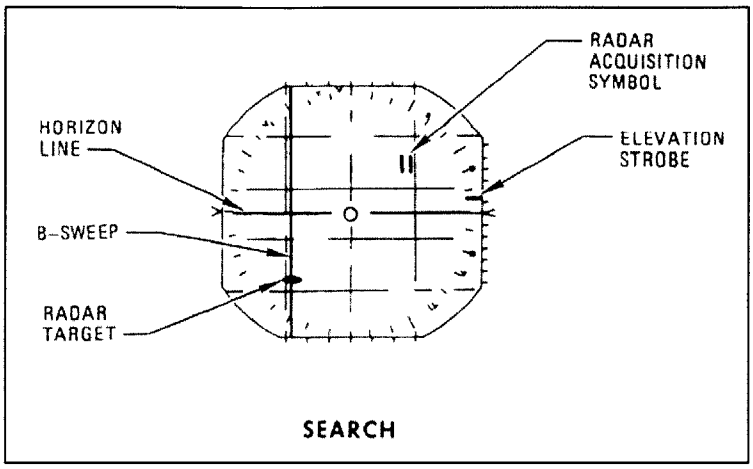

Figure 4.8. F-4C Radar B-Scope in Search.
(Source: *T.O. 1F-4C-34-1-1*, 1-27)

The F-4 radar in air-to-air mode used a B-scope display (figure 4.8), similar to that in the earlier F-86D with its E-4. During search, a vertical B-sweep line slid left and right across the display, with target blips appearing as the sweeping line passed over them. The left-right position of the blip indicated the relative azimuth of the target, measured from the attacking aircraft's nose. The vertical lines inscribed on the scope indicated thirty-degree increments left or right of the center vertical line, which corresponded to directly ahead or zero-degrees azimuth. The vertical position of the target blip indicated the range to the target, with the bottom of the scope representing zero miles. The maximum display range at the top of the scope was selectable by the GIB using the radar control panel. The options were 10 miles, 25 or 50 miles (the GIB toggled between the two scales using a button on the radar antenna control stick), 100 miles, or 200 miles, but most pilots regarded the longer scope ranges "of no value in air-[to-]air combat." The radar scope also included a horizon line that functioned like the aircraft's attitude indicator. Thus, the radar blip in figure 4.8 is approximately thirty-degrees left of the attacking aircraft and, assuming the radar is set to a twenty-five-mile scale, about six-miles away.[81]

The altitude of the target is not displayed on a B-scope. Instead, the F-4 used an elevation strobe located on the right side of the radar scope to indicate the elevation angle of the radar antenna. The small horizontal tick marks located on the outside of the display provided a scale, with each tick mark indicating ten-degrees above or below level. Thus, in

[81] *T.O. 1F-4C-34-1-1*, 1-12-25, 1-27; *T.O. 1F-4C-2-19*; Attinello, *Air-to-Air Encounters in Southeast Asia: Account of F-4 and F-8 Events Prior to 1 March 1967*, 196.

figure 4.7, the radar antenna is currently aimed about twelve-degrees high. With the target about six-miles away, the GIB would need to mentally compute that twelve-degrees high corresponded to an altitude difference of about 7,200 feet.[82]

An individual target blip only told the GIB where the target aircraft was at the present moment; it did not necessarily tell the GIB where the Phantom needed to aim to effect an appropriate cutoff. Also, all target blips didn't necessarily correspond to actual targets; many were spurious radar signals. To distinguish between actual and false targets and to gain an initial understanding of the intercept geometry, the GIB needed to watch the target blip for a few radar sweeps and assess its relative movement on the scope. A consistent target blip on each sweep generally indicated an actual target. If the radar blip was also steadily tracking straight down the scope (track 1 in figure 4.9), then the GIB also knew that the two aircraft were on a collision course. If the target drifted to one side or the other (for example, tracks 2 through 5 in figure 4.9), then the GIB knew that the two aircraft were not on a collision course. By assessing the amount and direction of the blip's movement on the scope, a well-trained GIB could quickly develop a mental image of the intercept.[83]

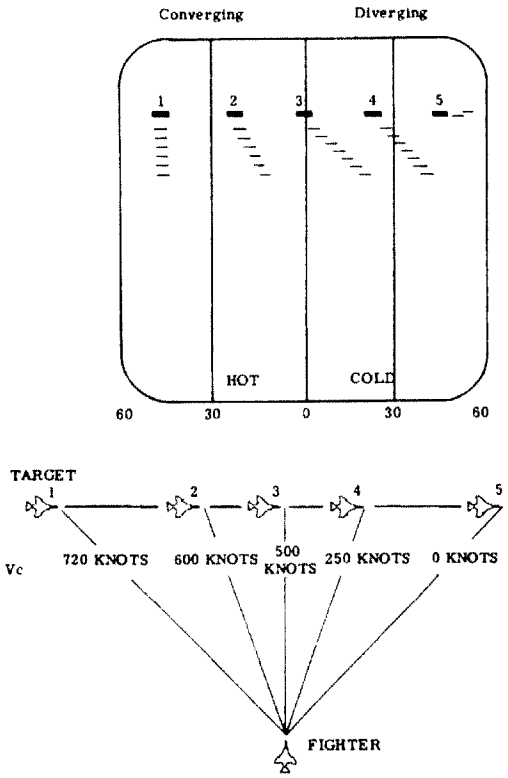

Figure 4.9. Assessing Target Drift on the Radar Scope.
Assuming the target and fighter are flying at the same airspeed, observing the relative drift of the traget on the radar scope provides important information on the geometry of the intercept. Placing the target blip farther on the "hot" side of the scope caused the two aircraft to converge faster; conversely, placing the target blip on the "cold" side of the scope slowered down the intercept. (Source: "Intercept Techniques," 20)

When the GIB wanted to lock on to the radar target, he used the antenna control stick (figure 4.10) mounted on the right side of the rear cockpit to maneuver the radar

[82] *T.O. 1F-4C-34-1-1*, 1–12–25, 1–27; *T.O. 1F-4C-2-19*; *4453d CCTW RTU Weapons School: Intercept Techniques*, 28. Altitude difference = angular difference x range in miles x 100.

[83] *4453d CCTW RTU Weapons School: Intercept Techniques*; *F-4C Intercept*.

acquisition symbol, a pair of ¼-inch vertical lines, over the target blip.[84] Once the acquisition symbol was placed over the target, the GIB then rotated the elevation wheel located on top of the antenna control stick until he obtained maximum target illumination before he initiated lock on using the paddle switch located near the base of the stick. A manual tracking mode was also available, but most GIBs relied on the automatic tracking mode, which was selected by depressing the paddle switch to its second detent.[85]

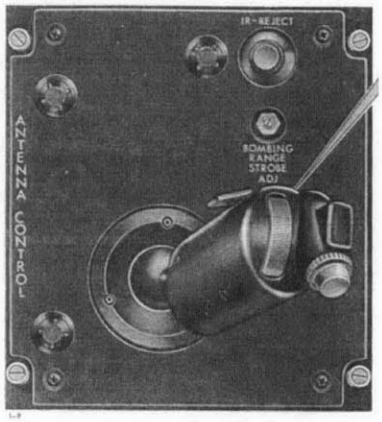

Figure 4.110. F-4C Antenna Control Stick (rear cockpit).
(Source: *T.O. 1F-4C-2-19*, 2-27)

With the radar in track, the symbology on the scope changed slightly (figure 4.11). The acquisition symbols were removed, replaced by two small dashes positioned along the B-sweep line that indicated the Sparrow missile's estimated maximum aerodynamic range (Ra) and its estimated minimum firing range (Rmin, computed as 0.2 of Ra). An allowable steering error (ASE) circle and an AIM dot also appeared. The ASE circle and the AIM dot were functionally similar to the steering dot and circle used in the F-86D's E-4: if the aircraft was maneuvered to position the AIM dot inside the ASE steering circle, then the aircraft would approach an optimum computed intercept profile. Also borrowing from the E-4, the F-4 used a circle with a gap in it to indicate the target's Vc. Whereas the gap in the range rate circle in the E-4 corresponded to a graduated scale marked on the scope's face, the F-4's display was supposedly more intuitive and used clock position. Hence, if

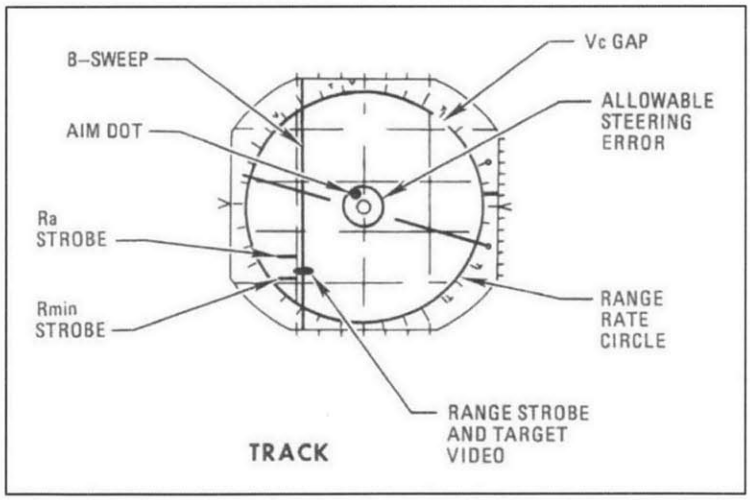

Figure 4.101. F-4C Radar B-Scope in Track.
(Source: *T.O. 1F-4C-34-1-1*, 1-27)

[84] The antenna control stick was also used to navigate some of the radar's other displays. For example, the azimuth coverage of the radar could be reduced from its normal 120-degrees to only sixty-degrees; in this instance, the position of the sixty-degree coverage was set using the antenna control. *T.O. 1F-4C-34-1-1*, 1–12–30.

[85] Ibid.; *T.O. 1F-4C-2-19*.

the gap in the F-4's range rate circle appeared in the nine o'clock position, then the target's Vc was 900 knots; a gap at three o'clock corresponded to 300 knots of Vc; and the gap in figure 4.11 would indicate about 150 knots closure. It wasn't quite that easy, though. For example, counterclockwise rotation from the twelve to nine o'clock position corresponded to negative Vc. There was also a switch that changed the clock position scaling, such that a gap at the nine o'clock position could also indicate 2,700 knots of closure. It was the sole responsibility of the GIB to keep all this straight.[86]

The additional information displayed during radar track made it easier for the GIB to monitor the target and update the intercept geometry. But because the GIB was not flying the plane, he could not actually maneuver the aircraft to refine the intercept. That was the job of the aircraft commander sitting in the front seat. To effect a successful radar intercept, the two trained pilots, individuals who Air Force instructors had designated for fighters based on their demonstrated self-sufficiency, needed to learn to work together in the cockpit. As one of the Phantom's training manuals noted, "Any discussion of the F-4C's fighter versus fighter capability must assume that the aircraft commander and pilot work as a team, continually anticipating the problems and needs of the other in performing the assigned combat missions." That included the GIB keeping "the aircraft commander informed of everything that he observes, either visually or on radar," and the aircraft commander being gentle on the flight controls since "high 'G' forces" and aggressive "maneuvering" made it difficult for the GIB to keep "his head in the optimum position for viewing the radar scope."[87]

The crews also had to learn a new vocabulary for communicating with each other over the Phantom's intercom. Already well-versed in the fighter pilot vernacular and recently introduced to the cryptic language of radar and radar intercepts, which included terms like B-sweep, ATA (antenna train angle), and TCA (track crossing angle), the crews now also had to learn "descriptive commentary." To facilitate effective and efficient intra-cockpit communication, the GIB was required to report radar targets to the aircraft commander in a standardized format: Azimuth in degrees from the nose, Elevation in degrees above or

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[86] *T.O. 1F-4C-34-1-1*, 1–12–30; *T.O. 1F-4C-2-19*. Of note, the radar contained several additional and more complex operating modes that could be used if the radar encountered electronic jamming. The GIB was expected to be completely familiar with these alternate operating modes as well.

[87] *F-4C Air Combat Tactics*, 18, 21.

below level, Range in miles, and Overtake in knots. Reflecting the Phantom's naval origins, "port" and "starboard" were used rather than "left" and "right." Hence, an appropriate radar point out from the GIB would be "30 port, 2 above, 5 miles, overtake 500." Moreover, there was a litany of other standardized terms, such as "easy port" (a request for a fifteen-degree banked turn to the left), "harder" (increase the current bank angle by fifteen degrees), and "down more" (increase the current descent rate by 1,000 feet per minute).[88]

As envisioned, the Phantom was supposed to simplify air combat tasks, automating many of them within the aircraft or otherwise allocating them to the missile armament. One mid-1962 McDonnell advertisement for the Phantom boasted of the "hundreds of test missions" flown in the simulator that pitted the human crew, with their "manual and mental capabilities," against an "electronic competitor." The simulations supposedly allowed the engineers to optimally distribute tasks between the "two man crew" and the aircraft's "advanced radar, fire control, instrumentation, and communication systems." Nevertheless, the Air Force and its fighter pilots quickly learned that the resulting optimum arrangement was still exceedingly complex. All told, it took more than 400 hours of ground training to qualify just one new Phantom aircrew for basic operations, a five-fold increase over the training requirements of a mid-1952 Sabre pilot. The burdensome academic load is one apt indication of the dramatic shift in pilot tasks and responsibilities that accompanied the new fighter.[89]

It may have been a thinly veiled jab at the new two-seat, twin-engine Phantom and its future crews, or it may have just been serendipitous, but the editors at *Fighter Weapons Newsletter* decided to include a poem in the journal's June 1962 edition, which they placed immediately after the glowing evaluation of the new Phantom. Titled "Ode to a Fighter Pilot" and accompanied by an image of a single fighter pilot looking up at his monstrous, single-engine F-105, the amateur poem reflected the myth of the fighter pilot as an isolated warrior who soars among the clouds.

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[88] Ibid.; *4453d CCTW RTU Weapons School: Intercept Techniques*, 2–9; *F-4 Aircrew Operational Procedures*, 61. To avoid confusion, intra-aircraft "commentary" used slightly different terms than the "brevity code" that fighter pilots used when communicating between aircraft. Brevity code terms included, for example, "angels," to indicate altitude in thousands of feet, "no joy" to indicate the target could not be found, or "Clara" to indicate that there were no enemy targets detected by the radar.

[89] *Combat Crew Training Course: F-4C*, 1–2; *Radar Academic Training Course: F-4C*; *USAF Replacement Training Course: F-4C*, 2–3; *Format for the Syllabus of Instruction: F-86*, 2–3; "Advantage Is Here: Why the Phantom II Has a Two Man Crew."

Oh, you knights of modern times with armor strapped so close around;
You fly your noble craft to awesome heights and speeds
Forever knowing the danger lying close beneath.
Of *single-powered flight* where lonely screw or loosened blade
Can halt you rapid flight and bring you quickly down,
You know not where.

The poem's last sentence proved foreboding:

One day the nation and the world will be aware of these fine men;
Until that time the lonely vigilance will last,
And communism will stand deterred from conflict, large or small.[90]

Within three years, the United States would find itself embroiled in another conflict intended to stop the spread of Communism, and as the poem's author predicted, the nation would once again have the opportunity to be made "aware" of her "fine" fighter pilots and their exploits.

Thrust into War, Again

The first Air Force Phantoms to journey across the Pacific Ocean left MacDill AFB, located near Tampa, Florida, on December 8, 1964. Although the eighteen F-4Cs from the 12th TFW weren't then destined for war—their destination was instead Okinawa, Japan—they demonstrated that the service's barely one-year old fighters, along with their aircrews and accompanying maintenance and support personnel, were ready to leave the comforts of home and journey half-way around the world when called upon.[91] That call to arms came four-months later when on April 4, 1965, aircrews from the 45th TFS, 15th TFW, taxied their Phantoms into position at the end of MacDill's runway, lit their afterburners, and thundered off to war. After overnight stops in Hawaii and Guam, the eighteen F-4Cs finally touched down at Ubon RTAFB on the seventh. Having just spent twenty-one of the last sixty hours in the cramped Phantom cockpit, the aircrews were told that they were needed

[90] Smith, "Ode to a Fighter Pilot." Emphasis added.

[91] *History of the 12th Tactical Fighter Wing, Jul - Dec 1964*, 1:19–20; Thornborough and Davies, *Phantom Story*, 92; Davies, *USAF F-4 Phantom II MiG Killers, 1965-68*, 8; *History of the 15th Tactical Fighter Wing, Jul - Dec 1965*, 1:v–vi, 20–26.

back in the air as soon as possible. So, sixteen hours later, the 45th's Phantoms were airborne, ready to battle MiGs.[92]

By the time of Operation Bolo in January 1967, there were more than ten times the number of Phantoms supporting the Vietnam War than what the 45th brought with them in April 1965.[93] The Phantom became the Air Force's workhorse during the war, remaining in continuous combat over Southeast Asia (SEA) until the final ceasefire was signed on January 27, 1973. The 45th's tenure in combat, though, was brief; it lasted just four months before they returned home to MacDill, replaced at Ubon by the 47th TFS in late July. Following the 47th's four-month deployment, which ended in December 1965, the Air Force realized that its plans to rotate in-tact squadrons through SEA on four-month stints wasn't sustainable, and it thereafter elected to semi-permanently base its aircraft in the region and instead rotate personnel and aircrews through on a year-long or 100-combat mission tour, whichever milestone occurred sooner.[94]

Countless Phantom aircrews would subsequently have an opportunity to experience combat first-hand. They operated from a handful of bases in Vietnam and Thailand, and they flew three different radar- and missile-equipped versions of the Phantom during the course of the war: the F-4C, the F-4D, and the F-4E. I focus primarily in this section on the first two Phantom deployments, though, as they identified many of the opportunities and challenges that the future F-4C pilots and their GIBs would face as they struggled to learn how to use their new aircraft and its weapons in both air-to-air and air-to-ground combat. While this project centers on the air-to-air experiences of the fighter aircrews, it is especially important in the F-4 case to also understand the bombing missions that consumed much of the Phantom aircrews' efforts during the Vietnam War.

The air war over Vietnam had already begun by the time the 45th TFS arrived at Ubon. The Gulf of Tonkin incident, in which North Vietnamese patrol boats allegedly attacked US Navy ships on August 2 and 4, 1964, led to the first American air attack against

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[92] *History of the 15th Tactical Fighter Wing, Jul - Dec 1965*, 1:17–19; Alden to 9 AF, "TACOP Final Report for 45 TFS."

[93] Hone, "Southeast Asia," 521.

[94] Van Staaveren, *Gradual Failure*, 146–48, 210; Beisner, "End of Tour Report"; Diefendorf, "End of Tour Report." On the effects of the policy, see Michel, *Clashes*, 166.

NVN, conducted on August 5 by carrier-based Navy fighters and fighter-bombers.[95] Following the action, the Air Force quickly reoriented its tactical forces within the region. Its first direct attacks against North Vietnamese infiltration routes into northern Laos were launched on December 14 as part of operation "Barrel Roll." The first Air Force strike used only six F-105s and eight supporting F-100s, a pittance compared to what was soon to come.[96] North Vietnamese insurgent attacks against American army facilities near Pleiku and Qui Nhon in South Vietnam (SVN) on February 7 and 10, 1965, respectively, resulted in another round of bombing attacks against the North. Flaming Dart I (February 7-8) and Flaming Dart II (February 11) used a mixture of Air Force and Navy aircraft to strike a variety of North Vietnamese military targets. Little more than a week later, President Lyndon Johnson authorized a program of "sustained US bombing of North Vietnam." The resulting Operation "Rolling Thunder" would roll on for nearly three years, characterized throughout by extremely close civilian oversight and repeated, temporary pauses as American officials searched for any possible conciliatory response from the North.[97]

At the start of Rolling Thunder, the Air Force had approximately 200 tactical aircraft in the theater, the bulk of jets being F-100 Super Sabres and F-105 Thunderchiefs. For the first Rolling Thunder strikes conducted on March 2, the Air Force used nearly half of its force in the region to attack an ammunition dump: twenty-five F-105s and twenty B-57s provided the bombing effects, while another fifty-eight total F-105s, F-100s, and RF-101s were mustered to provide flak suppression, air cover, and tactical reconnaissance support.

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[95] Van Staaveren, *Gradual Failure*, 48–51. There is an abundance of literature on the Gulf of Tonkin incident, the American's reprisal attack, and Congress's ensuing resolution that granted President Lyndon Johnson the authority to "take all necessary steps, including the use of armed force," to pursue objectives in Vietnam. See, for example: Goulden, *Truth Is the First Casualty*; Galloway, *Gulf of Tonkin Resolution*; McNamara, *In Retrospect*; Moïse, *Tonkin Gulf*.

[96] Van Staaveren, *Gradual Failure*, 50–51, 58– 63. The Air Force had been supporting the fledgling Laotian air force's attacks against the same target set for nearly two months prior.

[97] Ibid., 9–25; *Flaming Dart Air Strikes*; McNamara, *In Retrospect*, 170–74; Tilford, *Setup*, 102–4; Clodfelter, *Limits of Air Power*; Pape, *Bombing to Win*, chap. 6. For decades, Rolling Thunder would be cited as a model of failed diplomacy and poorly executed military strategy. Commenting on the administration's close oversight of Rolling Thunder, especially at the start of operations, the 2d Air Division Commander, General Moore stated: "I was never allowed in the early days to send a single airplane North [without being] told how many bombs I would have on it, how many airplanes were in the flight, and what time it would be over the target." Quoted in Van Staaveren, *Gradual Failure*, 83.

The same day, the Air Force sent another quarter of its tactical force to support a South Vietnamese-led attack against a different target.[98]

The Air Force lost five fighters during those first attacks—three F-105s and two F-100s. They were brought down not by MiGs, but by ground-fire. Their routes to the target and their maneuvering confined by geography, trained to approach their targets low and fast, and equipped with weapons designed for the same, Air Force fighter pilots were particularly susceptible to the "unsophisticated" ground-fire that often congregated around the limited number of suitable bombing targets in NVN. Small arms fire would eventually account for almost half of the Air Force's more than 1,600 aircraft lost in combat in SEA from January 1962 to June 1973. Larger-caliber anti-aircraft artillery (AAA) claimed another 26 percent.[99]

The American pilots had another set of ground-based weapons to worry about, which one Phantom pilot noted "were faster than enemy planes and carried a much larger bang than antiaircraft fire. They were guided and homed in on you.... They chased you down to kill you."[100] The Soviet's SA-2 guided surface-to-air missile (SAM) had already proven its lethality five-years earlier when it shot Francis Gary Powers's U-2 spy plane out of the sky over the Soviet Union. Hence, when American intelligence officials observed SA-2 sites popping up around Hanoi beginning in April 1965, they were understandably dismayed (figure 4.12). However, concerns over collateral damage and fears of potential war escalation led to the Johnson administration's decision to place the new SAM sites off-limits to attack. Three months later, after the SA-2 sites had been completed and

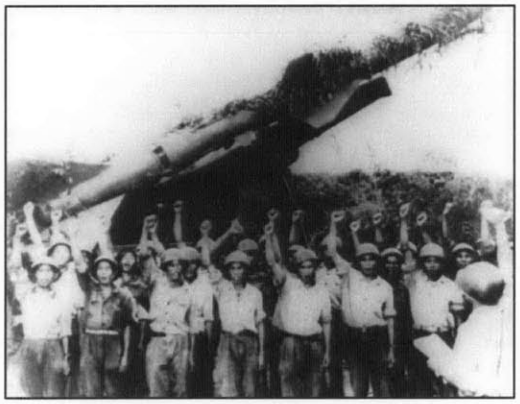

Figure 4.12. North Vietnamese SA-2.
(Source: NMUSAF)

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[98] Van Staaveren, *Gradual Failure*, 69–70, 83–84; Andrews, "To Fly and Fight," 61–63.

[99] Scott, *Soviet Bloc AA Weapons*; Momyer, *Airpower in Three Wars*, 134–36; Van Staaveren, *Gradual Failure*, 84–89; McCrea, *US Navy, Marine Corps, and Air Force Fixed-Wing Aircraft Losses*, 1–15; Hone, "Southeast Asia," 541; Cunningham, "William W. Momyer," 172. Momyer described the AAA defenses around Hanoi and Haiphong as rivaling that of Germany's best-defended targets in World War II. Van Staaveren noted that after the initial Rolling Thunder attacks, Secretary of the Air Force Eugene Zuckert worried that the service might lose its "credibility" if its advanced tactical aircraft continued to be lost to "unsophisticated" enemy weapons. The Air Force initiated several studies trying to discern a pattern in its losses to AAA. See, for example: English, Marlow, and Sandborn, *Reduction of Tactical Fighter Losses*; Marlow and English, *Reduction of Tactical Fighter Losses*.

[100] Quoted in Andrews, "To Fly and Fight," 132.

ringed with defensive AAA, the North Vietnamese opened fire. The first missiles, launched on July 24, 1965, brought down one F-4C and damaged three others in the formation, one severely. The attack occurred just as the 45th TFS was beginning to trade out with the 47th TFS.[101]

At first, the new SAMs were extremely lethal, on average scoring a victory for every eighteen missiles fired. Commonly described as a "flying telephone pole," the SA-2 was nearly thirty-five-feet long, reached a top speed of Mach 3.5, and packed a nearly 300-pound warhead. Riding the beam provided by its accompanying ground-based Fan Song radar (like the first Sperry Sparrows), the missile could attack targets anywhere between 3,000 feet and 50,000 feet altitude out to ranges in excess of seventeen miles. Improved American countertactics and electronic countermeasures introduced by 1968 significantly reduced the effectiveness of the SAMs, and eventually it took on average more than 100 SA-2 missiles to bring down an American aircraft. Nonetheless, with nearly 6,000 SA-2s launched between July 1965 and March 1968, the SAMs proved a constant and deadly menace. Describing their impact on the Air Force's tactical air operations, the commander of the 47th TFS declared: "The advent of the Surface to Air Missile has changed things considerably. It denys [*sic*] the free use of airspace above 3000 feet AGL [above ground level] in a SAM defended area. To complicate matters further there has been a significant improvement in the employment of AAA and AW [automatic weapons]. In short you can't fly high enough to avoid SAM's and you can't fly low enough or fast enough to avoid ground fire."[102]

The American aircrews also had to contend with enemy fighter planes. At the start of Rolling Thunder, the North Vietnamese Air Force (NVAF) possessed thirty-four Soviet-built MiG-15s and MiG-17s, located at its new airfield at Phuc Yen. The NVAF MiG-15s

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[101] Van Staaveren, *Gradual Failure*, 113–14, 161–73; Langguth, "US Aides Indicate a Red Missile Hit Jet"; Gaspard, *SA-2 Deployment and Tactics*; Alden to 9 AF, "TACOP Final Report for 45 TFS," 6; Robinson to C15, "Report of the 47th TFS Deployment."

[102] Robinson to C15, "Report of the 47th TFS Deployment," 13; Van Staaveren, *Gradual Failure*, 163–64; Gaspard, *SA-2 Deployment and Tactics*; Baldwin, "US Raids 2 Missile Sites"; Hone, "Southeast Asia," 528–34; Andrews, "To Fly and Fight," 128–44; Anderegg, *Sierra Hotel*, 21–22; *8th TFW Tactical Doctrine*, March 1967, 38–43; Handley, *Nickel On The Grass*, 124n64; McCarthy, *Phantom Reflections*, 30–31, 76; Olds, "End of Tour Report," 1–2; Momyer, *Airpower in Three Wars*, 142–48; Futrell et al., *Aces and Aerial Victories*, 5–7; Michel, *Clashes*, 28–29, 31–38; Werrell, *Chasing the Silver Bullet*, 48–50; McCrea, *US Navy, Marine Corps, and Air Force Fixed-Wing Aircraft Losses*, 1–15. Anderegg described the SA-2 as "fast but not agile." Fighter pilots eventually realized that if they "saw they missile coming, [they] could evade it easily by first diving to pick up some airspeed. Then, once the missile committed down toward him, the pilot would pull back up into the SAM and cause it to overshoot and miss. Aircraft hit by SAMs were almost always jets whose pilots never saw the missile." In total, SAMs would account for about 7 percent of total Air Force aircraft losses during the war.

were nearly identical to those used in the Korean War more than a decade earlier, and their MiG-17s were only slightly faster and not much better. Both MiG-types retained the combination of 23- and 37-mm cannon armament from the prior war. But, the MiGs were small and nimble, and the Air Force quickly realized that its supersonic fighters were not well-equipped, nor its pilots well-trained, to deal with the threat. For example, Olds would later note that the MiG-17 "could give you a tussle the likes of which you never had before in your life." Moreover, the MiGs didn't need to actually shoot down any aircraft to disrupt the American bombing attacks; merely arriving on-scene and threatening the Americans could cause the bomb-laden fighter-bombers to jettison their heavy ordnance as they turned to defend themselves. With the North Vietnamese enjoying the benefit of a network of ground-based radar facilities that could detect the American aircraft approaching from a distance, and radar controllers that could precisely vector their pilots toward the large strike packages, American military officials soon realized that the once-discounted late-model MiGs could present a major problem.[103]

As in the Korean War prior, military officers argued that in order to conduct a strategic bombing campaign, they first needed to achieve air superiority. That in turn was best accomplished by first bombing the enemy's aircraft on the ground and destroying their accompanying airbases and air defenses. However, once again political considerations trumped military doctrine. At the start of Rolling Thunder, the Johnson administration placed many of the North's radar sites and all of their MiG airfields off limits to attack. Secretary of Defense McNamara did, however, on April 1, 1965, grant the military's request for a squadron of the Air Force's premier Phantoms to be deployed to the theater to help provide air cover against the MiGs. Three days later, the 45th TFS left MacDill for Ubon.[104]

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[103] Michel, *Clashes*, 16–20; Van Staaveren, *Gradual Failure*, 52, 70–71, 96; Olds, Oral History Interview, July 12, 1967, 8; Momyer, *Airpower in Three Wars*, 133–34; Harr, Muskat, and Williams, *Air Combat Tactics Evaluation Final Report*; Muska, "Featherduster"; Saunders, "PACAF Tactics/Techniques (Bulletin #8)"; Scott, *Counter-Air Tactics*. In the Featherduster tests, American pilots evaluated the relative effectiveness of their F-100s, F-104s, F-105s, and F-4Cs against the MiG-15/-17, which was simulated by an F-86. It was the second time the Sabre functioned as a proxy for the MiG; recall Boatner, "Letter Report on Relative Aerial Combat Capability." Regarding the effectiveness of the MiGs at causing American aircraft to jettison their ordnance, Futrell calculated that during the period from September to December 1966, "of the 192 strike aircraft actually engaged by MIG's, 107 (or 55.73 percent) jettisoned their ordnance." Futrell et al., *Aces and Aerial Victories*, 10.

[104] CSAF to TAC, "TWO BUCK Deployment"; Van Staaveren, *Gradual Failure*, 96, 241; Alden to 9 AF, "TACOP Final Report for 45 TFS"; Momyer, *Airpower in Three Wars*, 157; Futrell et al., *Aces and Aerial Victories*, 3–4; *F-4C System Package Program*, August 31, 1962, 5–3; Futrell, *Ideas, Concepts, Doctrine, 1907-1960*, chap. 7–8; Futrell, *Ideas, Concepts, Doctrine, 1961-1984*, chap. 3–4 and especially pages 237-38; Hone, "Southeast Asia." The

The MiGs struck twice before the Phantoms arrived. On April 3, 1965, three MiGs swooped in and attacked a group of Navy fighters that were bombing a North Vietnamese railway bridge, damaging one F-8 Crusader. The next day, as a flight of four heavily laden Air Force F-105s orbited ten-miles south of Thanh Hoa Bridge, waiting for their turn to attack, a pack of four MiG-17s dove "out of the haze" from the formation's high six o'clock. As they had the day before, the MiG pilots tore through the American formation on a high-speed, single-pass attack, with the two lead MiGs closing to 1,500 feet before they opened fire on the two lead Thuds. The MiGs' bullets found their mark and they downed the two aircraft, killing both pilots. The MiGs' sudden aggressiveness startled the Americans, which is partly why the 45th's pilots were ordered back in the air as soon as possible after they landed at Ubon.[105]

The 45th's Phantoms, loaded with four Sparrow and four Sidewinder missiles, immediately began flying MiG CAP (combat air patrol) for the larger Rolling Thunder missions, escorting their Thud brethren to and from the target areas. Perhaps wary of the Phantoms' presence, the NVAF MiGs continued to fly, but they stopped giving battle.[106] Although two Phantoms sighted a pack of eight MiGs loitering above them at the end of a mission on May 31, and four F-105s were harassed by a pair of MiG-15s three weeks later

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Joint Chiefs of Staff submitted their request to McNamara to move a squadron of Air Force Phantoms to Southeast Asia on March 19. The preferred doctrine for gaining air superiority was even written into the requirements documentation for the F-4C, which noted, "Ideally, the enemy's air arm should be destroyed on the ground with either conventional or nuclear weapons." Van Staaveren noted that "from November 14, 1964, to March 1, 1966, the [Joint Chiefs of Staff] ... officially asked McNamara on eleven occasions for authority to strike all of the north's important airbases, convinced that this would not substantially increase the risk of Chinese intervention in the war, but Washington's refusal to allow such attacks would endure for many more months." Momyer noted that the common argument "for not striking [MiG] airfields was that our aircraft losses would be disproportionate to the damage we could inflict upon the North Vietnamese Air Force. But our strike forces were already penetrating the areas where airfields were located, and there were no major changes in the defenses the enemy could have employed that would have made our losses greater than they already were against other targets in the area."

[105] "US Fliers Bomb 2 Bridges"; Langguth, "Hanoi MIG's Down 2 American Jets"; "Bomb Loads Slowed F-105's"; Van Staaveren, *Gradual Failure*, 106–9; Attinello, *Air-to-Air Encounters in Southeast Asia: F-105 Events Prior to 1 March 1967*, 35–41; Michel, *Clashes*, 8–10.

[106] Alden to 9 AF, "TACOP Final Report for 45 TFS"; Attinello, *Air-to-Air Encounters in Southeast Asia: Account of F-4 and F-8 Events Prior to 1 March 1967*, 57; Futrell et al., *Aces and Aerial Victories*, 22; Michel, *Clashes*, 21. The MiGs adopted a curious practice of launching as soon as their radar controllers detected American aircraft refueling over the Thai-Laotian border, but when the American aircraft approached, the MiGs would vacate the area, wait until the Americans completed their attacks, and then turn to follow the American strike package from a distance. Intelligence officials later figured that the MiGs and their radar controllers were conducting training, readying for the eventual day when they would turn south a little sooner and catch the Americans low on fuel and easy prey.

on June 24, air activity remained relatively calm. The next engagement between Air Force fighters and MiGs would not take place until July 10, 1965.[107] In the interim, with the MiG threat apparently in abeyance, the members of the 45th TFS turned their talents elsewhere, showcasing both their and their aircraft's remarkable versatility.

Jack of All Trades

Despite the Phantom's origins as a Navy interceptor optimized for carrier defense, Air Force officials from the outset planned to take full advantage of the Phantom's massive engines and the numerous hardpoints on its wings, from which they planned to hang all sorts of air-to-ground munitions. The Air Force had already swapped out the Navy's radar with a system better suited for air-to-ground work, and their first aircrews had received nearly as many training sorties devoted to practicing ground attack as they had for learning the new intercept tactics.[108] Consequently, with no MiGs willing to give battle, Air Force officials wondered if their Phantoms might be better used supporting the immediate task-at-hand. For the remainder of the war, Phantom aircrews would split their time between hunting MiGs and dropping bombs, with the latter often consuming the bulk of their efforts.

The first shift for the 45th TFS was from MiG CAP to Strike CAP. During MiG CAP, the Phantoms' sole mission was to defend the less maneuverable fighter-bombers from air attack. The mission usually required twelve Phantoms, arranged into three flights of four, all of which were configured exclusively for air-to-air combat. In addition to their eight missiles—four Sparrows and four Sidewinders—the Phantoms also usually carried two or three external fuel tanks to maximize their loiter time in the target area. The configuration for Strike CAP missions was similar, except that each Phantom carried three 750-pound general purpose bombs on its centerline station under the fuselage. The intent of Strike CAP

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[107] Attinello, *Air-to-Air Encounters in Southeast Asia: F-105 Events Prior to 1 March 1967*, 43–47; Attinello, *Air-to-Air Encounters in Southeast Asia: Account of F-4 and F-8 Events Prior to 1 March 1967*, 43–54. Navy Phantoms encountered MiGs on June 4 and June 17; everyone escaped the first encounter unscathed, but in the second, two of the four MiG-17s were shot down. An earlier engagement between four Navy Phantoms and four MiG-17s on April 9 was eventually determined to be an unfortunate mistake—the MiGs were Chinese, not North Vietnamese. In the ensuing confusion, one MiG was shot down and a Phantom lost, either to low fuel or an errant American missile. See Langguth, "One MIG Seen on Fire"; "Peking Reports Hainan Air Fight"; Van Staaveren, *Gradual Failure*, 110–11; Attinello, *Air-to-Air Encounters in Southeast Asia: Account of F-4 and F-8 Events Prior to 1 March 1967*, 35–42.

[108] *F-4C System Package Program*, August 31, 1962; *F-4C System Package Program*, September 1963; Meyer, "Phantom Over Tampa Bay."

was that the Phantoms would first fly MiG CAP until "the strike aircraft completed their bombing mission," and then, if no MiGs had been detected, the F-4Cs would "deliver their bombs on the target."[109]

In principle, Strike CAP made sense, but the aircrews of the 45th despised it. The squadron commander called it "probably the most degrading mission given to the F-4C." By attempting to be both an escort fighter and a bomber simultaneously, the Phantom was actually rendered incapable of doing either well. The "light bomb load" was tactically ineffective and it severely degraded the F-4's performance. Burning more fuel due to the bombs' extra drag, Phantom pilots on Strike CAP missions routinely ran low on fuel and had to jettison their bombs while they were still providing escort duties for the Thuds. The 45th TFS's commander estimated that 25 percent of the Phantoms' bombs carried during the Strike CAP missions never made it to the target area. "This," he declared, "is a waste of aircraft and munitions."[110]

Later that summer, the Phantoms began trading in their Sidewinders for bombs as they started flying "straight air to ground bombing missions." The aircrews were allowed to keep their Sparrows because those missiles didn't take up space that could otherwise carry a bomb, and they theoretically provided an air-to-air self-defense capability. After some experimentation in air-to-ground tactics, the aircrews in the 45th TFS settled on a forty-five-degree dive-bomb attack, starting from between 11,500 and 13,500-feet AGL, and ending with bomb release at 5,000 feet AGL. During the bombing attack, the GIB functioned as an "oral altimeter," calling out the Phantom's altitude as it descended "down the chute"—"10-5, 9-5, 8-5, 7-5, ready, pickle"—while the front seater focused his attention on lining-up with the target.[111] The Phantoms also began flying a variety of other air-to-ground missions that

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[109] Alden to 9 AF, "TACOP Final Report for 45 TFS," 1–2, 5–6; Attinello, *Air-to-Air Encounters in Southeast Asia: Account of F-4 and F-8 Events Prior to 1 March 1967*, 57. A shortage of centerline fuel tanks during the 45th's deployment meant that often only two external fuel tanks were carried. The 45th's Recce Escort and Queen Bee Escort missions were functionally similar to MiG CAP. During Recce Escort, the Phantoms escorted a tactical reconnaissance aircraft such as an RF-101. Queen Bee escort missions were grueling seven-hour sorties—requiring six aerial refueling—covering "a C-130 flying a classified mission in the Gulf of Tonkin," likely gathering communications and signals intelligence.

[110] Alden to 9 AF, "TACOP Final Report for 45 TFS," 6.

[111] Ibid., 1, 4; Sokol, interview; Welch, interview, October 1, 2013; Hargrove, Oral History Interview, 30–32; Van Staaveren, *Gradual Failure*, 138; Attinello, *Air to Air Encounters in Southeast Asia: Account of F-4 and F-8 Events Prior to 1 March 1967*, 43. Van Staaveren states that the Phantoms first started flying bombing missions at the end of May 1965, but the sorties were likely Strike CAP missions instead of dedicated bombing missions. Attinello notes that the Phantoms' MiG sighting on May 31, 1965, occurred after the Phantoms were "climbing

summer, all of which required different types of ordnance, including unguided air-to-ground LAU-3A rockets and SUU-16 external, podded 20-mm Gatling guns. The variety of assigned missions and corresponding ordnance, each with different employment procedures and weapons parameters, added a significant layer of complexity to Phantom operations.[112]

Figure 4.13. Route Pack Structure in North Vietnam.
(Source: Adapted from Attachment 1 to *History of the 366th Tactical Fighter Wing, Oct 1966 – Mar 1967*, vol 1)

By the end of 1965, as bombing operations over NVN continued to intensify, the bulk of Phantom operations were devoted to air-to-ground missions. For example, during the 47th TFS's four-month tenure at Ubon from August to December 1965, only a third of their 1,743 combat missions were for MiG CAP.[113] The ramped-up bombing also led to in the infamous Route Pack (RP) structure, by which NVN was divided into seven geographic areas (figure 4.13).

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out from air-to-ground delivery after MIGCAP," a typical Strike CAP profile. On the mechanics of manual dive bombing in the Phantom, see Anderegg, *Sierra Hotel*, 5–9.

[112] Alden to 9 AF, "TACOP Final Report for 45 TFS," 1–2; Robinson to C15, "Report of the 47th TFS Deployment," 10; Raddin, "End of Tour Report," 21. One of the additional missions was Road Recce, which entailed weaving alongside a designated road at high speed and low altitude, usually about 450 knots and 5,000 feet, searching for targets to destroy with an assortment of bombs, rockets, or bullets from their gun pod. The requirement for the Phantom to carry a podded, external gun was added by TAC in April 1962. On the SUU-16, see *History of the Tactical Air Command, Jan - Jun 1962*, 1:251n75; *History of the Tactical Air Command, Jul - Dec 1962*, 1:238–39; Mehserle, *Capability of the F-4C Aircraft/SUU-16/A Gun Pod*; *F-4C/SUU-16A*; Broadway, "Have Guns"; Fino, "Breaking the Trance."

[113] Robinson to C15, "Report of the 47th TFS Deployment," 5, 9–10, 12. Exemplifying the versatility of the two-seat Phantom, some missions were designated as Photo Chase, which entailed following a strike package over the target and having the GIB use a hand-held camera to snap pictures of the target.

Intended to simplify inter-service coordination issues, Navy aircraft operating from their carriers positioned off the coast at "Yankee Station" eventually assumed responsibility for targets in RP II, III, IV, and VIB. The Air Force was primarily responsible for targets in RP I, V, and VIA, which subjected Air Force fighters to long transits over hostile regions. A massive aerial refueling operation along the Thai-Laotian border consequently took shape, becoming itself a staple of Vietnam air operations.[114]

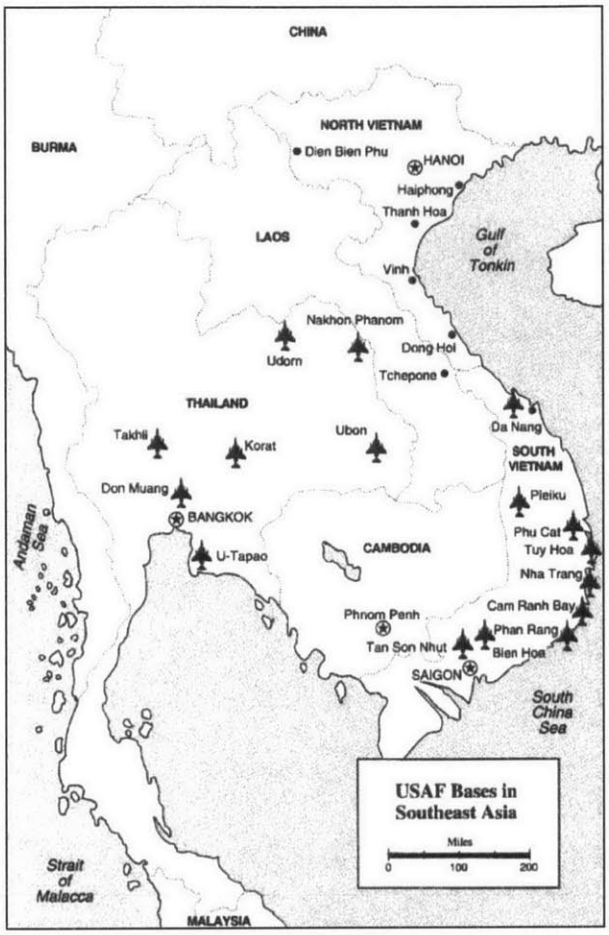

Figure 4.14. USAF Bases in Southeast Asia. Although the bases are all marked with F-4 silhouettes, not all bases had Phantoms. The primary F-4C/D bases during Rolling Thunder were Ubon, Cam Ranh Bay, and DaNang. (Source: Hone, "Southeast Asia," 521)

Over the course of the following year, the Air Force consolidated its growing force of F-4Cs in the region into three wings: the 8th TFW at Ubon RTAFB, Thailand; the 12th TFW at Cam Ranh AB, SVN; and the 366th TFW at DaNang AB, SVN (figure 4.14).[115] The Phantoms also continued to add to their air-to-ground repertoire. The aircrews began flying radar bombing missions, armed recce missions at night, and, as the number of US Army troops in the region grew, close air support missions to support them. The 8th TFW's tactics manual reflected both the growing diversity of the Phantom's air-to-ground missions and their relative weight of effort. For

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[114] Momyer, *Airpower in Three Wars*, 58, 103–112; Braswell to Yudkin, "Background Material on SEA Command and Control"; Michel, *Clashes*, 38–39; Van Staaveren, *Gradual Failure*, 209–10, 240; Thompson, *To Hanoi and Back*, 18–19; Cunningham, "William W. Momyer," 171–72; *History of the 366th Tactical Fighter Wing, Oct 1966 - Mar 1967*, 1:10; Momyer, "Evolution of Fighter Tactics in SEA." Momyer noted that prior to Vietnam, "air refueling of fighters was considered a means of deployment, rather than an accepted procedure for the employment of these forces."

[115] Hone, "Southeast Asia," 521, 524. The 12th TFW moved to Cam Ranh in November 1965, and the 8th TFW set up shop at Ubon in December 1965. The 366th TFW eventually established itself at DaNang in March 1966.

example, the December 1967 version of the manual, revised after the recent arrival of the F-4D at Ubon, was over 300-pages long, but fewer than seventy-five of those pages were devoted to air-to-air tactics and MiG CAP operations.[116]

The Air Force's updated F-4D version of its Phantom was designed to help with the expanding air-to-ground mission set. The D-model airframe itself was little changed from that of the earlier F-4C. Among the (purported) improvements, the F-4D carried the Air Force's IR-guided Falcon missile, now termed the AIM-4D (discussed in more detail in the next subsection). The new Phantom also came equipped with a stabilized lead-computing optical gunsight (somewhat similar to the earlier A-4 gunsights) that could be used during air-to-ground operations with the external SUU-16 or SUU-23 20-mm gun pod. Most significantly, though, the new Phantom included a new bombing computer, the AN/ASQ-91 automatic Weapons Release Computer System (WRCS).[117]

Whereas the original F-4C had a bombing computer of its own, it was so quirky and unreliable that few pilots even tried to use it in combat; hence, the 45th's preferred tactic of a straight-in forty-five-degree dive attack followed by bomb release at an estimated altitude above the ground. With the new WRCS in the F-4D, the attack approach was the same, but once the Phantom was pointed at the target, the GIB could use the radar to essentially lock on to the ground around the target and feed that range information directly to the bombing computer. The pilot then centered the "servoed" gunsight's pipper over the target, depressed the bomb release button, a.k.a. the "pickle button," and initiated an immediate recovery from the dive—the WRCS automatically released the bombs at the proper time during the dive recovery. Using the new system, the GIB was no longer relegated to the role of "oral altimeter," and the bombing patterns could be completed almost 2,000 feet farther away from the target and its potentially lethal defenses. After the war, Olds remarked that the new WRCS worked "very well.... It improved our bombing accuracy tremendously." However, Anderegg, a former F-4 GIB, later front seater, and eventual Air Force historian, noted that

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[116] Anderegg, *Sierra Hotel*, 3–4, 14–15; *8th TFW Tactical Doctrine*, March 1967; *8th TFW Tactical Doctrine*, December 1967; Olds, "End of Tour Report," 14–17. The March 1967 version of the 8th's tactics manual was almost 230 pages, of which thirty were devoted to air-to-air tactics and MiG CAP operations.

[117] Knaack, *Encyclopedia of US Air Force Aircraft*, 1:273–77; Olds, "End of Tour Report," 11–13; McInerney, "LCOS"; McInerney, "F-4D"; Bugos, *Engineering the F-4*, 125–26; Thornborough and Davies, *Phantom Story*, 108. Getting the AIM-4D onto the F-4D was a top Air Force priority; regrettably, the missile did not perform well in combat, as will be discussed below. The F-4D also included a "redesigned equipment cooling system and number 1 fuel cell."

the system remained finicky. Moreover, some pilots maintained the belief that "dive bombing in the direct [manual] mode … was the manly man's way to attack a target," and, consequently, the use of the automatic function of the WRCS often "brought scorn and derisive hoots of laughter from old heads."[118]

The variety of air-to-ground missions performed by the Phantom aircrews, and their proficiency in executing them, provides an important reminder that the F-4 combat experience in Vietnam was not focused solely on downing enemy MiGs. Indeed, with the limited number of enemy aircraft and the pilots' relatively short tours of duty, few Phantom aircrews actually had an opportunity to engage a MiG. While their Rolling Thunder missions might at times seem a lost cause as they repeatedly bombed targets that possessed little political or military significance, William Andrews observed that the aircrews nevertheless felt "duty-bound to use the immense power [of their aircraft] … to help fellow combatants, especially American soldiers." Supporting Andrews' assessment, one Phantom pilot, Jerry Cook, remembered the surge of adrenaline, pounding heart, and "eagerness to help" whenever he heard the call, "ground troops in trouble." Jere Wallace, an F-100 pilot who would go on to fly F-4s and later F-15s, expressed a similar sentiment, "The most rewarding mission for me was getting some [Army] grunts out of trouble."[119]

Nevertheless, the allure of a potential MiG kill remained an intense attraction for the majority of Phantom aircrews. Momyer noted that the F-4 pilots "all wanted to get a MiG." Cook wrote that he left Vietnam in October 1966 feeling "somewhat unfulfilled," for despite flying "every air-to-air mission that I could to the north, it [the opportunity to fight a MiG] just never happened." In one instance, when it was suggested that aircrews should become specialized and fly only a limited number of mission types rather than the entire mix, the pilots howled in anguish, saying that it would be unfair for those of them not assigned to the

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[118] Thornborough and Davies, *Phantom Story*, 108; Olds, Oral History Interview, n.d., 78; Olds, "End of Tour Report," 11–13; McCarthy, *Phantom Reflections*, 87–88; Buhrow, Oral History Interview, September 28, 1967, 22–24; Anderegg, *Sierra Hotel*, 63–64; McNally, "WRCS"; McInerney, "F-4 Dive Toss." In addition to the radar and new gunsight, WRCS relied heavily on the Phantom's inertial navigation system.

[119] Andrews, "To Fly and Fight," 12; Welch, interview, October 1, 2013; Cook, *Once a Fighter Pilot*, 170–72; Wallace, interview. Cook, however, also remembered one "personally devastating mission" in which he was directed to drop napalm on his own troops. Initially rebuffing the FAC's direction, Cook was told, "The commander on the ground wants the napalm down on top of him and his troops. He says that they're dug in and the enemy is overrunning them. He says do it now or they're all dead anyway!" Cook dropped the napalm, and he"received word later that day … that our mission had been a success," but he said he emerged "deeply wounded with a scar that would always be there."

MiG CAP role. The 8th TFW's tactics manual likewise stoked the pilots' enthusiasm with its declaration, "Air-to-air combat is the utmost test of a fighter pilot's skill." In short, like their Korean forebears, Phantom pilots longed for the opportunity to land from a mission, be greeted on the tarmac by a cheering throng, and then paint a red star on the side of their jet.[120] A handful of members of the 45th TFS had the opportunity to experience the phenomenon first-hand during their deployment. In the process, they also revealed many of the issues that would plague the Phantom's performance in air-to-air combat for the duration of the war.

Air-to-Air Frustrations

On July 10, 1965, a pair of F-4Cs from the 45th TFS scored the Air Force's first MiG kills of the war. For weeks prior, the Americans watched as their MiG adversaries practiced chasing down American aircraft. Assigned to fly MiG CAP on the tenth for a group of F-105s tasked with striking an ammunition depot in Yen Bai, about thirty-miles northwest of Hanoi, the Phantom aircrews of Mink flight hoped to catch the MiGs in their usual routine. Hence, the four Phantoms took off fifteen-minutes late and snuck into the target area. When the MiGs turned to follow the strike package, the Phantoms raced north to intercept them. Four-minutes later, two MiG-17s had been shot down by Sidewinder missiles. In the *New York Times* article that followed two-days later, one of the pilots, Major Richard Hall, described the engagement as "almost a schoolbook exercise."[121]

In reality, it wasn't. Hall and his GIB, Lieutenant George Larson, flying in the lead Phantom as Mink 1, first detected the MiGs from thirty-three-miles away. They couldn't shoot, though, because there was no way to know that the radar targets were not other friendly aircraft. In fact, the Americans' rules of engagement (ROE) required a visual

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[120] Kimball, Oral History Interview, 24; Hendrickson, Oral History Interview, 28; *8th TFW Tactical Doctrine*, March 1967, 97; Nash, "Project CORONA HARVEST End of Tour Report," 11–12, 44–47, 49; Cook, *Once a Fighter Pilot*, 211–15, 219; Momyer, "Evolution of Fighter Tactics in SEA," 62; McCarthy, *Phantom Reflections*, 68–69, 166. Cook noted the he "wanted a MiG, badly." On one occasion, he thought he would have his chance, even imagining the "headlines in my hometown paper, 'Captain Cook downs two MiGs over North Vietnam.' I had waited and trained for this moment for years." Fortunately, just before he squeezed the trigger to launch a Sidewinder missile, the target turned and Cook learned that he had intercepted not MiG-21s, but a pair of Navy F-8s. See also Andrews, "To Fly and Fight," 80, 144–62; Tilford, *Setup*, 127–30.

[121] "Pilots Describe Downing of MIG's." The description of the engagement is based on the following accounts: Attinello, *Air-to-Air Encounters in Southeast Asia: Account of F-4 and F-8 Events Prior to 1 March 1967*, 55–77; Scott, *F-4C - MIG-17 Engagement*; Michel, *Clashes*, 8, 20–24; Futrell et al., *Aces and Aerial Victories*, 4–5, 22–26; Davies, *USAF F-4 Phantom II MiG Killers, 1965-68*, 8–10.

identification (VID) of the target before launching a missile at it. To satisfy the restriction, the pilots in the 45th TFS planned to send the two lead Phantoms racing ahead eight to ten miles in full afterburner toward the targets. If the targets were hostile MiGs, then the lead element would radio the trailing Phantoms, which would still be in an optimum position to fire their Sparrow missiles. That day, though, the Phantom elements only achieved about three-miles separation. Consequently, at the time of the identification pass, the trailing element was already too close to the MiGs to fire their missiles.[122]

Even had there been sufficient range, the trailing Phantoms would have still had difficulties. Mink 4's radar had spouted a leak in its wave guide tube, which rendered its radar incapable of automatic target tracking. Moreover, the radio intercom in the jet broke, leaving the GIB and the pilot unable to communicate with each other. The crew in Mink 3 was not much better off. Their radar also failed, which led to significant confusion in the cockpit when the GIB tried to tell the pilot to use a Sidewinder and the pilot told the GIB to get a radar lock so that he could use a Sparrow.

Nonetheless, Mink 3 and 4 were able to exploit their thrust advantage to power high- above the MiGs before diving down into position to fire their Sidewinders. The pair of Phantoms fired a total of eight Sidewinders at the pair of MiGs. Four of the Sidewinders veered off course from the start, two because the pilots had failed to first check that the missiles had detected the MiG target. Of the remaining four missiles, two appeared to detonate near the targets but failed to bring the MiGs down, and the remaining two, one against each MiG, finally did the job. It took less than ninety seconds from the time of the identification pass to the shootdown.[123]

The single engagement foretold of many of the issues that would plague the Phantoms' performance in air combat over Vietnam: the onerous requirement to perform a VID of the target before launching a missile; unreliable radars, and consequently unreliable radar-guided missiles; finicky heat-seeking missiles, and front seaters that had a tendency to

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[122] Alden to 9 AF, "TACOP Final Report for 45 TFS," 5.

[123] During the engagement, the lead Phantom climbed to 24,000 feet and orbited the area to monitor the engagement. The Number 2 Phantom extended away from the fight searching for additional MiGs, since the Phantom crews were told to expect the MiGs to attack in four-ships. Unfortunately, the crew then lost sight of the fight, and by the time they had reoriented themselves, the engagement was over. The day after the mission, each victorious two-person F-4 crew was awarded a Silver Star; the aircrews from the accompanying F-4s received Distinguished Flying Crosses.

fire them out of parameters; and miscommunications and tension within the Phantom cockpit. I address the first three now and save the last for the next subsection.

The requirement to positively identify a radar target as hostile before firing a missile was not unforeseen. When the Air Force began procuring the missile-only Phantom, it was assumed that the target's identification could be determined and relayed to the aircrews by ground or airborne controllers using their radars. The F-4C's requirements documents made explicit reference to the assumption. It warned that if the F-4s were to be deployed to an austere region that lacked the radar coverage network, and if the aircrews were "required to use a visual means of identifying targets before missile launch," then "the advantages of the Sparrow [would be] nullified."[124]

In Vietnam, the Phantom aircrews were faced with exactly that hypothetical scenario, exacerbated by the constrained geography of the region and the limited coordination among the different American aircrews. For example, Air Force fighters approaching from the west would frequently see on their radar scopes other Air Force or Navy aircraft approaching targets from the east. Years later, General William Momyer, who served during Rolling Thunder as the commander of Seventh Air Force and who was therefore responsible for all tactical air operations in SEA, complained that because of the VID requirement, the Air Force had "forfeited our initial advantage of being able to detect a MiG at thirty to thirty-five mile range.... Many kills were lost because of this restriction." Momyer might have been able to change the air-to-air ROE, but he never did. He deemed fratricide more probable and more costly than the prospect of losing an American aircraft to the limited number of enemy MiGs. And, despite their grousing about the VID requirement, many aircrews admitted that "they preferred [it] to shooting down one of their own aircraft by mistake." Indeed, on one occasion a late VID saved Cook the ignominy of shooting down a pair of Navy F-8s.[125]

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[124] *F-4C System Package Program*, August 31, 1962, 5–13. The F-100D aircrews using the GAR-8 came to the same conclusion in 1959, noting that "the greatest limitation ... in employing the GAR-8 ... is the inability to positively identify a fighter target as friend or foe at the range from which GAR-8's are normally fired." Giordano, "F-100D GAR-8 Tactics," 43.

[125] "Pilots Describe Downing of MIG's"; Momyer, *Airpower in Three Wars*, 156; Cook, *Once a Fighter Pilot*, 209–15; McCarthy, *Phantom Reflections*, 29; Mohamed, "Case for Recognition," 22. Mohamed asserted that "visual identification remains both the primary and best means by which to determine friend or enemy."

Throughout the war, the Air Force worked to improve its network of ground and airborne radar coverage, hoping one day to shift some of the fighters' identification and ROE burden to the radar controllers. For example, the morning that the 45th left MacDill for Ubon, Air Force EC-121Ds, specially converted Lockheed Super Constellations with bulbous antennas mounted above and below the fuselage, departed McClellan AFB in California for SVN. The EC-121s specialized in aerial surveillance, but their radar system was optimized for target detection over water, not the mountains and valleys of Vietnam. Using the callsigns "Big Eye," "College Eye," and "Disco" during the course of the war, the EC-121s were never able to reliably detect targets below 8,000 feet. Consequently, while they could broadcast alerts of general MiG activity—"yellow" provided a warning that MiGs were in the air, while a "red" call indicated an imminent danger to American aircraft—the EC-121s were unable to relieve the Phantoms of the stringent VID requirement.[126]

Tactics, and later new technologies, were also enlisted to help the aircrews satisfy the ROE. For example, Olds carefully orchestrated Operation Bolo to provide the first three flights of F-4s with clear lanes and temporary "missile free zones," which meant that the Phantoms could immediately fire on any radar target they detected. However, when the MiGs failed to climb up to meet the Phantoms and Olds flight turned back toward Ford flight, Colonel Olds had to abruptly cancel the free-fire zones, "holler[ing] out loud and clear, 'Don't shoot. Come off missiles free.'"[127] The dual technological developments of Combat Tree, which was installed on some late-model F-4Ds and allowed the Phantoms to interrogate the MiG's radar transponder, and TISEO (Target Identification System, Electro-

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[126] Michel, *Clashes*, 46–51, 250–53; Van Staaveren, *Gradual Failure*, 117–18; Scott, *Big Eye Task Force*; Scott, *EC-121D Operations*; Olds, "Briefing to the Staff of Project CORONA HARVEST on Operation BOLO," 67; Futrell et al., *Aces and Aerial Victories*, 4, 12–16; Momyer, *Airpower in Three Wars*, 168–76; Attinello, *Air-to-Air Encounters in Southeast Asia: Account of F-4 and F-8 Events Prior to 1 March 1967*, 58, 95–97; Cook, *Once a Fighter Pilot*, 211–15. Of note, Cook's near-shootdown of the Navy fighters came after the EC-121 warned him of unidentified aircraft nearby. There were also frequent communications issues between the EC-121 aircraft and the Phantoms. For example, during the July 10, 1965, engagement, the Big Eye crews reported that they issued several MiG warnings to the Phantoms, but the Phantom crewmembers indicated that they never received them. Olds also complained of the generic MiG warnings, noting that the calls applied to a thirty-by-thirty-mile sector of airspace; which equated to "Forty-five thousand cubic miles of sky, and you tell me there's a bloody MiG in there. It's stupid-useless information." Later during Operation Linebacker, the Navy would lend its own radar control capability to the air fight over North Vietnam using the callsign "Red Crown." Additionally, the aircrews started receiving signals intelligence under the callsign "Teaball" informing them of the MiGs' activities.

[127] Olds, "Briefing to the Staff of Project CORONA HARVEST on Operation BOLO," 27, 32; Asay, Covington, and Stone, *History of Operations BOLO*, 8–9.

optical), essentially a television camera with a telephoto lens mounted in the F-4E's left wing root, both eventually proved helpful, but neither arrived in time for use during Rolling Thunder.[128]

The VID requirement also exacerbated known limitations with the Phantom's missile ordnance. As noted earlier, both the Sparrow and Sidewinder incorporated proximity fuses that increased the missiles' chances of destroying the target. However, their inclusion in the design necessitated a larger, safe-minimum missile employment range—3,000 feet—in order to preclude the possibility of a missile fusing and detonating near the launching aircraft. Against the anticipated enemy bomber threat, the missiles' minimum range was not expected to be an issue. But, when facing a nimble MiG that could quickly turn to meet an approaching Phantom head-on, and that was also so small that the Phantom pilot could usually only obtain a positive VID inside of one mile, the missiles' minimum range proved to be a "definite handicap." Analogizing their predicament, Air Force fighter pilots' frequently said they were given a "spear" or a "rifle" before being locked in the cramped confines of a "phone booth" or "closet" to battle "knife" or "pistol" wielding MiGs.[129]

Furthermore, the performance of the Phantom's longer-range "spears" was at best lackluster.[130] Entering Vietnam, the Sparrow was expected to hit the target 71 percent of the

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[128] Michel, *Clashes*, 181, 194–95, 267–69; Anderegg, *Sierra Hotel*, 33–34. Combat Tree appeared in 1971; TISEO in late 1972.

[129] Michel, *Clashes*, 16; Anderegg, *Sierra Hotel*, 32; Blesse, Corona Ace Oral History Interview, 59–60; Cook, *Once a Fighter Pilot*, 209–10; Dilger, Oral History Interview, 24; Buhrow, Oral History Interview, September 28, 1967, 19–21; Robinson to C15, "Report of the 47th TFS Deployment," 11, 14. Dilger noted that "when you get at the Rmin [minimum range] of the missile and Rmax [maximum range] of the eyeball, they start coinciding with each other, and you've got an almost impossible situation." Many pilots continued to favor development of a better, more maneuverable air-to-air missile with a shorter minimum range over a gun. For example, one pilot claimed following an engagement on April 23, 1966, "The need for F-4 gun is overstated, although it would be of value if it could be obtained without hurting current radar and other systems performance. If you are in position to fire [a] gun, you have made some mistake. Why, after a mistake, would a gun solve all [your] problems.... If the F-4 had guns, we would have lost a lot more, since once a gun duel starts the F-4 is at a disadvantage against the MiG." Quoted in Attinello, *Air-to-Air Encounters in Southeast Asia: Account of F-4 and F-8 Events Prior to 1 March 1967*, 142, 161.

[130] Surprisingly, the Air Force seemed vaguely uninterested in the performance of the Phantom's missiles when it first started taking delivery of its new F-4Cs. During TAC's "limited evaluation" of the F-4C, conducted by the 558th TFS, 12th TFW, at MacDill AFB in August 1964, air-to-air testing was assigned a "relatively low test project priority." Of the forty-six scheduled Sparrow shots, only seventeen sorties were flown and of those, only four successfully launched the test missile. All four test launches were later "termed non-productive" due to failure of the telemetry scoring system. No Sidewinder missiles were launched during the test. Despite the inconclusive findings, the evaluation report was optimistic, declaring, "The F-4C [air-to-air] delivery capability is somewhat apparent." *F-4C Limited Evaluation*, 55–59.

time. It never came close to that number.[131] For example, at the end of April 1966, one Phantom pilot reported that "confidence in Sparrow was low at this point; there had been 13 firings with no hits in the previous week."[132] A team of Phantom and Sparrow specialists sent the following month to investigate the situation and "recommend the required actions necessary to enhance success of future Sparrow/Sidewinder firings" reached an unsettling conclusion. They reported that even "assuming proper maintenance of both aircraft and missiles, the probability of kill with the Sparrow can be expected to be low."[133]

The Air Force, in partnership with the Navy, eventually fielded two additional versions of the Sparrow missile during Rolling Thunder. The AIM-7E arrived in mid-1966 to replace the earlier AIM-7D. The next Sparrow, the AIM-7E-2, only saw limited action in Rolling Thunder but became the primary Sparrow version used when air-to-air hostilities resumed in 1972. Neither missile lived up to the hype, though. For example, hailed as the "dogfight Sparrow" because of its shorter minimum range and supposedly improved capability against maneuvering targets, the AIM-7E-2 scored only thirty-four hits out of 281 firings over the course of the war, a dismal 12 percent success rate.[134]

The Phantom's complex radar shared some of the blame for the Sparrow's poor combat tally. The uninspiring performance of the 45th TFS's Phantoms' radars in the July 10, 1965, battle was not atypical. The delicate electronic components in the Phantom frequently succumbed to the corrosive heat and humidity of the region. Olds's team at Ubon spent weeks "peaking" their aircraft in preparation for Operation Bolo, but it demanded maintenance personnel working sixteen to eighteen-hour days and the pace proved

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[131] Michel, *Clashes*, 156.

[132] Attinello, *Air-to-Air Encounters in Southeast Asia: Account of F-4 and F-8 Events Prior to 1 March 1967*, 141–50, 196. Of the five Sparrows fired during a mission on April 23, 1966, one was launched inside its minimum range, two missiles' motors never ignited after launch, one missile guided but missed the target, and one hit and downed a MiG. The Phantoms also fired two Sidewinders during the day's battle; one was fired without a valid tone and the other hit and destroyed a second MiG.

[133] Scott, *F-4C Fighter Screen and Escort*, 6, 10; Michel, *Clashes*, 15–53, 156–58. Extracts from the Heat Treat team's SEA trip report were distributed as an attachment to the article. The team found that during the period from April 23 to May 11, 1966, Air Force F-4Cs fired thirteen AIM-7s (and tried to fire an additional three which never left the aircraft) to down a single MiG—a 6 percent hit rate. Whereas some failures could be attributed to faulty missile maintenance and aircraft loading or improper pilot performance, the team noted that "four of the Sparrows launched during the period 23–24 April were fired under ideal conditions and missed" for inexplicable reasons. See also the Navy's investigation of their aircraft armament in Ault, *Report of the Air-to-Air Missile System*.

[134] Michel, *Clashes*, 150–53, 182, 279; *Project Red Baron II*, 13; Burns, Oral History Interview, June 5, 1984, 223–25. On the performance of the 8th TFW's AIM-7 missiles, see Olds, "End of Tour Report," 8.

unsustainable. It was later said that on average, the Phantom required thirty-seven man-hours of maintenance for every single hour of flight. Moreover, even when "peaked," the Phantom's pulsed-radar was physically incapable of reliably detecting targets flying at low altitude. If a target dove towards the ground or behind a ridge, the radar would inevitably break lock and any Sparrow missiles in the air would be lost.[135]

The Sidewinder performed markedly better than the larger, more complex Sparrow, but the IR-guided missile's 28 percent hit rate in April and May 1966 still fell short of its originally advertised success rate of 65 percent. Whereas the Sparrow was plagued by technical issues, the Sidewinder's poor performance could often be traced to improper employment outside of its operating specifications. Complaining of its exceptionally restrictive firing envelope, one Phantom pilot declared the AIM-9B Sidewinder "totally hopeless in the air-combat environment." Another pilot was only slightly more optimistic, reporting, "It's a damn fine little missile *if* you can get the thing launched under the right parameters."[136]

Despite the Sidewinder's relative success and continued Navy investments toward improving it, the Air Force made an ill-fated decision to equip its new F-4Ds with the service's AIM-4D Falcon, offspring of Hughes GAR-4A. The AIM-4D retained the Falcon's diminutive warhead and contact-only fusing, which continued to limit its capability against small, maneuvering targets. Complicating matters, the aircrews found the missile's employment procedures extremely cumbersome.[137] One postwar analysis concluded that the

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[135] Olds, "Briefing to the Staff of Project CORONA HARVEST on Operation BOLO," 12–13; Olds, Oral History Interview, n.d., 10–11, 68–69; Olds, "End of Tour Report," 8–9; Asay, Covington, and Stone, *History of Operations BOLO*, 94–101; McCarthy, *Phantom Reflections*, 59; Kirk, Oral History Interview, 5; Dilger, Oral History Interview, 23; Hendrickson, Oral History Interview, 44–45. Olds claimed that the "break rate" on the F-4 was 92 percent, "meaning that about 92% of the time a guy taxis into the flightline, there is [something wrong with the jet. It] may only take 15 minutes to fix and on the other hand it may take 5 or 6 hours." On the performance of the "peaked" equipment in Bolo, see also Ow, *Mission Bolo.*

[136] Michel, *Clashes*, 43, 153–58; *USAF Tactical Fighter Weapons Center Interim Report #2: SEA Ordnance Firing Analysis*, 3; Dilger, Oral History Interview, 25–26; Kirk, Oral History Interview, 3. Emphasis added. See also assessments in Olds, Oral History Interview, n.d., 69–70; Olds, "End of Tour Report," 10.

[137] Michel, *Clashes*, 110, 156; Westrum, *Sidewinder*, 177; Thornborough and Davies, *Phantom Story*, 110; *Project Red Baron II*, 13. The Navy pressed on and developed the AIM-9D, which included a new PbS target detector cell to improve the missile's tracking and IR-discrimination capability. The new detector, however, needed to be cryogenically cooled. Lacking sufficient room within the missile body to store a supply of nitrogen gas, Navy engineers elected to redesign the missile rail to accommodate the bottle and pipe the gas to the missile seeker. This design allowed the missile to cool for almost four hours.

The Air Force's AIM-4D Falcon also used a cooled IR-seeker, but its nitrogen supply was contained in the already small missile-body. Hence, the AIM-4D had only two minutes of cooling time available, and once

55 percent of the AIM-4Ds were fired outside of parameters. After experiencing numerous missile failures first-hand, Olds declared the new Falcon "no good" and he ordered them removed from his Wing's Phantoms. Thereafter, the Air Force elected to design its own AIM-9E Sidewinder, but the new missile did not reach the theater until after Rolling Thunder concluded. Its performance never matched that of the Navy's improved AIM-9D.[138]

Figure 4.15. F-4E Phantom II.
Note the long bulge under the aircraft's nose which housed the F-4E's internal 20-mm, six-barrel Gatling gun. (Source: NMUSAF)

Whereas the F-4D represented a significant improvement in the air-to-ground capability of the Air Force's Phantom, the next version of the F-4 announced in October 1966 promised to address many of the Phantom's air-to-air deficiencies. Most notably, the new F-4E sported an internal 20-mm Gatling gun housed under the radome, which, the *New York Times* reported, "will complement the plane's missile capability and should give it superiority in both long-range action and close combat" (figure 4.15). The new F-4E was also supposed to incorporate a radical new radar system that promised an unparalleled ability to detect low-flying targets, but Hughes's coherent-on-receive Doppler system failed to materialize in time. Instead, the F-4E received an only slightly improved and smaller APQ-120 radar set. The first of the new Phantoms did not arrive in SEA until November 1968.[139]

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started it could not be stopped. Thus, "the F-4D pilot had a choice: either arm the AIM-4D early in the engagement and hope he would get a chance to use it within the next two minutes, or wait and try to remember to arm it after the fight began and when there was a target available. In a turning dogfight where shot opportunities were fleeting, such restraints on a missile clearly were unacceptable."

[138] Olds, Oral History Interview, n.d., 70–74; Olds, *Fighter Pilot*, 314; Michel, *Clashes*, 111, 156. Since the new F-4Ds were no longer configured to support the Sidewinder (only the Falcon), the aircraft had to be rewired to accept the old AIM-9B missiles. On the perceived advantages of the Navy's AIM-9D versus the Air Force's AIM-9B, see Hargrove, Oral History Interview, 14. From then on, the Air Force and Navy developed separate Sidewinder missiles produced under separate contracts. The disparity between the services' different versions would have implications a decade later during AIMVAL-ACEVAL. On the different Sidewinder production models, see Beck, "State of the Art."

[139] "Air Force Orders New Jet Fighter"; "US Jets Will Reflect Lessons"; Bugos, *Engineering the F-4*, 158–59; Thornborough and Davies, *Phantom Story*, 113–14; Knaack, *Encyclopedia of US Air Force Aircraft*, 1:278–80; McInerney, "F-4E"; McInerney, "F-4E Cat III"; Bielinski, "F-4E." The Air Force fighter pilots yearned for the F-4Es arrival; see for example Kirk, Oral History Interview, 7. The F-4E would undergo numerous upgrades during the course of the war as part of the Rivet Haste program, including a new cockpit design, leading edge

Each new technological advantage, be it a gadget, weapon, or aircraft model, levied a new demand on the aircrews as they struggled to maintain proficiency in the variety of missions performed by the Phantom. Moreover, the aircrews also had to adapt to the changing MiG tactics. At first, the NVAF used its MiG-15s and -17s to conduct single-pass, slashing attacks reminiscent of Korea. New tactics emerged after the NVAF started receiving the small, delta-winged Soviet MiG-21 in the latter half of 1965 (figure 4.16). The new supersonic fighter possessed remarkable maneuverability and quick acceleration, and it also provided the North Vietnamese with an air-to-air IR-guided missile capability in the form of the AA-2 Atoll, a pirated version of the American's Sidewinder (some MiG-21s also packed an internal 30-mm cannon for additional, close-range firepower). Thereafter, the North generally reserved its limited numbers of MiG-21s for use in quick, high-altitude, missile attacks while it deployed its more numerous MiG-17s at low altitude, in what became known as "wagon wheel" formations, waiting to ambush unsuspecting American fighter-bombers en route to their targets. All of the NVAF pilots took advantage of their country's extensive radar network and ground controlled intercept capability.[140]

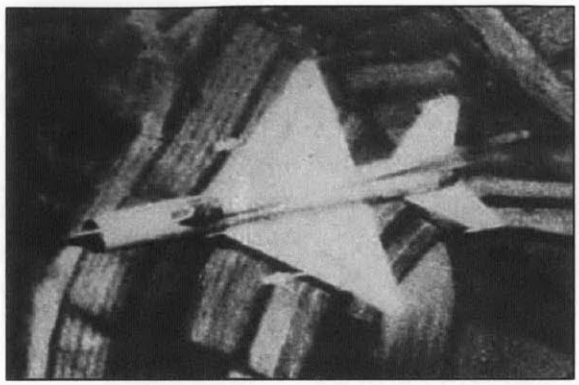

Figure 4.16. Soviet MiG-21.
(Source: Hone, "Southeast Asia," 530)

MiG activity waxed and waned throughout Rolling Thunder based on the weather and the intensity of American bombing. For example, increased American bombing in NVN beginning in Spring 1966 brought the MiGs up, and they remained very active through the end of the year. The MiGs' activity immediately declined following Operation Bolo, but a new round of intense American bombing in April and May 1967 stirred the hornet's nest again. The Air Force responded by increasing its number of F-4s dedicated to MiG CAP.

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slats for improved stability at high AOA, and TISEO. Beck, "Super Phantom." See also Handley, *Nickel On The Grass*, 70n30; Anderegg, *Sierra Hotel*, 32–35.

[140] Michel, *Clashes*, 40–59, 75–90; Futrell et al., *Aces and Aerial Victories*, 26; Momyer, *Airpower in Three Wars*, 154–62; Olds, "End of Tour Report," 4–6; Buhrow, Oral History Interview, September 28, 1967, 24; *Project Red Baron II*, 8–9; Hone, "Southeast Asia." PACAF issued a warning about the MiG-21 to its aircrews in a May 1965 tactics bulletin, which included excerpts from a Soviet MiG-21 tactics manual so that the American pilots might anticipate how the Soviet fighter would likely be employed. Aust, "PACAF Tactics and Techniques Program (Bulletin #5)," 5. MiG-19s did not appear in North Vietnam until after Rolling Thunder had ended.

After a series of aerial victories that summer, it appeared that the Americans had finally defeated the MiGs. Momyer in August proudly proclaimed to a Senate subcommittee, "We have driven the MiGs out of the sky for all practical purposes." Momyer's assessment proved overly optimistic, though. The MiGs returned with a vengeance in the fall, and by December 1967, the NVAF pilots were executing more complex and well-coordinated attacks. Three months later, the US began curtailing its Rolling Thunder operations and any chance of engaging a MiG evaporated. Phantom aircrews would have to wait until the resumption of bombing with the Linebacker operations in 1972 before they would have a chance to claim another MiG.[141] In the end, though, the air combat tallies in Vietnam never matched the impressive numbers of the Korean War.[142]

An oft-overlooked component of the narrative is the changes that were taking place in the Phantom cockpits as the pilots and their GIBs struggled to adapt to the challenges of air combat over Vietnam. New human-machine relationships in both the front and rear sections of the cockpit were being formed. There were also profound tensions in the interpersonal relationships that linked pilots with GIBs and Phantom aircrews with Phantom aircrews. Collectively, these new relationships were subtlety transforming what *flying* a Phantom in combat meant. The picture that the *New York Times* editors selected to accompany their account of the 45th TFS's victories on July 10, 1965, alluded to one of the possible outcomes. Whereas in the past pilots were usually photographed proudly standing near their aircraft's open cockpit, the crew of the victorious Phantom was photographed crouching under the wing of their aircraft, the GIB and aircraft commander each pointing to a Sidewinder missile. The title of the picture made no mention of fighter pilots, but instead labeled the two flightsuit-wearing aviators "successful missilemen."[143]

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[141] Michel, *Clashes*, 72–74, 90–91, 99, 113, 118–19, 127–31, 139–40; Olds, "End of Tour Report," 3–5; Weaver, *Air-to-Air Encounters over North Vietnam, 1 Jul 1967 - 31 Dec 1968*, 28–29; Cunningham, "William W. Momyer," 280–81, 285.

[142] On the kill ratios in Vietnam, see Sayers, "Red Baron Reports." During the first half of 1967, American F-4s destroyed thirteen MiG-21s with no losses, but in the last quarter of 1967, North Vietnamese MiG-21s successfully downed twelve American aircraft, five of them Phantoms, while suffering only one loss.

[143] "Pilots Describe Downing of MIG's."

Tension in the Air

In November 1966, shortly after Olds arrived at Ubon and took command of the 8th TFW, the Air Force filed a news release announcing the rare occurrence of having two ace pilots in charge of a fighter wing in Vietnam. Olds had earned his acehood with his 24½ kills in World War II. His vice commander, Colonel Vermont "Pappy" Garrison, now a "wise old sage" at age fifty-one, had claimed eleven victories in the Second World War and then another ten in Korea. Asked to compare his prior combat experience with that in the Phantom over Vietnam, Olds remarked, "These young lieutenants today have a far more difficult task than we had with the less sophisticated aircraft of World War II. It's difficult to compare the F-4C Phantom with the 'seat of the pants' flying in the old P-51 'Mustang.'"[144]

Olds's brief remark made explicit reference to one of the challenges the Phantom aircrews confronted over Vietnam—figuring out their "sophisticated" aircraft. The task was complicated by the fact that, although the aircrews had undergone months of training figuring out how to use their new aircraft and its systems, they soon learned that neither their aircraft nor their training was especially well-suited for the air war they encountered over Vietnam. The 8th TFW tactics manual made note of the discrepancy:

> The F-4C/APQ-100/APA-157 weapons control system and associated armaments, the AIM-9B and the AIM-7E, are designed to be employed in a non-maneuvering environment using close control. This close control coupled with the long ranges of the armament provide an element of surprise and thus a high probability that the target will be in a non-maneuvering state. Further, the system was designed more as a defensive rather than an offensive system. *The chances of employing the system in this manner in SEA are very remote.*[145]

Olds's remark, however, also alluded to more than just the pure technological differences that separated the Phantom from the earlier Mustang. Of course the Phantom was a more complicated piece of technology. Nonetheless, it still was "difficult" for Olds to draw a meaningful comparison. The Phantom, despite its complexity, was in some ways easier to fly and operate. In other ways, it was infinitely more challenging.

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[144] "'Ace' Fighter Wing Commanded by 'Aces'"; Olds, Corona Ace Oral History Interview, 83; Olds, *Fighter Pilot*, 241.

[145] *8th TFW Tactical Doctrine*, March 1967, 78. Emphasis added. "Close control" occurs when an individual fighter is directed against an individual target using precise vectors provided by either a ground-based or air-based radar operator.

Each Phantom front seater and his GIB would have to negotiate the unique opportunities and challenges associated with operating the F-4C in combat. Moreover, these interactions continued to take place within the context of the classic fighter pilot myth. Were the Phantom crews still "flying knights"? Had they become "flying scientists"? Or were they something different, like the "successful missilemen" referenced in the *New York Times* caption? Inevitably, tension and conflict surfaced as the pilots wrestled with these questions, both within the Phantom cockpit and between Phantom cockpits.

Tensions in the Cockpit

By the end of the Vietnam War in 1973, the Phantom was recognized as "the big dog on the porch" within TAC circles.[146] Prior to then, however, before the single-seat F-100s and F-105s had faded into history, the Phantom had lost some of its initial luster. Not every fighter pilot was thrilled about sharing his space in the cockpit with another man, and the Air Force's preferred policy prior to 1969 of assigning junior, newly winged lieutenants to the Phantom's back seat fueled the tension. Confronting the sometimes acrimonious interpersonal dynamics within the cockpit became as critical an element to the Phantom's overall combat performance as each individual's efforts to sort out the more technical challenges associated with his position in the cockpit.

For the young lieutenants emerging fresh from pilot training prior to 1969, the F-4C seldom rose to the top of their wish lists.[147] Clifton, Olds's GIB during the Bolo mission, was excited about earning an F-4 assignment after pilot training, but he admitted that it wasn't his first choice: an F-105 was, but the lone Thud that class went to the top graduate and it wasn't Clifton. Lieutenant Howard Hill was also disappointed when he found out that he was going to be thrown into the back seat of the Phantom. An El Paso, Texas native, Hill graduated from the US Air Force Academy in 1965, a year after Clifton. Like Clifton, Hill got to experience the thrill of flying the supersonic, needle-nosed T-38 Talon in the skies around Del Rio, Texas, during pilot training. "We had soloed.... We had flown formation; we had done all sorts of things," Hill remembered. "A lot of us were thinking we would be

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[146] Anderegg, *Sierra Hotel*, xii.

[147] On the process by which a new pilot declared his preferences for an aircraft type, and ATC's attempt to be more accommodating, see: *History of the Air Training Command, Jan - Jun 1963*, 1:98–99; Connor to Pilot Training Wings, "Undergraduate Pilot Training Assignment Procedures"; Tips to Pilot Training Wings, "Undergraduate Pilot Training Assignment Procedures"; Wood to ATCCS, "Final Report - UPT Assignments."

single-engine jocks." But when the assignments were revealed, three-quarters of the "young tigers" in Hill's class found out that they "were going to be put in the back seat with another man." Nonetheless, Hill did his best to adopt the "fighter pilot's bravado and the swagger" as he rolled into his F-4 radar training course. He and the other future GIBs didn't fool Colonel Frank Everest, the commander of the first Phantom training unit at MacDill. Everest remembered how the new GIBs "hated" sitting in the back seat; "it was demoralizing" for them.[148]

The single-engine F-105's appeal to the newly winged lieutenants is telling. It was a big and fast jet, but old, certainly not agile, and, as Olds poignantly noted, it had "a bomb-bay in it, for Christ's sake." The Thud was also suffering grievous losses over Vietnam. A pair of analyses conducted in mid-1966 concluded that an F-105 pilot had only a 70 percent chance of surviving his 100-combat mission tour. In contrast, the pilots in the F-4C enjoyed a 96 percent chance of completing their assignment.[149] The F-105's loss rates weren't a secret either. For example, many pilots, including Hill, joked that an "optimist was an F-105 driver that smoked two packs of cigarettes a day and thought he was going to die of lung cancer." Facing challenging missions and long odds on a daily basis, the Thud pilots earned the almost-universal respect of the other fighter pilots.[150]

Hence, with the Thud pilots' "valor and performance … fast becoming legend," it's not difficult to appreciate the young fighter pilots' enchantment with the thought of *flying* a Thud on a bombing mission as opposed to *riding* in a Phantom staring at blips on a screen. Some Phantom instructors tried to entice the new pilots, advertising that "the discriminating young fighter pilot recognizes that the F-4 is not only the most versatile plane in combat today, but that it will be with us for many years to come. Sooner or later, those who want to stick with supersonic fighters will have to transition into it." The sales pitch rarely worked,

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[148] Clifton, "There I Was...2"; Clifton, "There I Was...4"; Hill, Oral History Interview, iv, 20–22; Everest, Oral History Interview, 13. Clifton's pilot training class was one of the first to fly the new Northrop T-38 Talon advanced jet trainer. Graduating from pilot training a year later, Thomas Sokol had a similar experience, "If you wanted to go to fighter and you weren't the number one guy in your class, you went to the back seat of an F-4." Sokol, interview. See also Buhrow, Oral History Interview, September 28, 1967, 43–44.

[149] Scott, *Probability of Southeast Asia Tour Completion*; Hughes, *Probability of Tour Completion for Pilots*.

[150] Olds, Corona Ace Oral History Interview, 13, 54; Hill, Oral History Interview, 37; McCarthy, *Phantom Reflections*, 13; Welch, interview, October 1, 2013; Cook, *Once a Fighter Pilot*, 195–95; Andrews, "To Fly and Fight," 39–40, 55. On the F-105 experience in Vietnam, see: Broughton, *Thud Ridge*; Rasimus, *When Thunder Rolled*; Bell, *100 Missions North*; Sherwood, *Fast Movers*, chap. 2. Jeff Cliver, a young pilot who was able to finagle an F-105, remarked that "the best way" to start flying fighters was in a single-seater: "You never count on anybody else. It's all you, baby, so figure it out." Cliver, interview.

though, and the older single-seat fighters continued to draw the top graduates from pilot training. Still, for the remainder who continued to dream of one day being a fighter pilot, at least the back seat of a Phantom was far better than the right, co-pilot seat of a transport, bomber, or tanker. Plus, Phantom GIBs like Thomas Sokol, who grew up near an airport and spent his time "star[ing] at airplanes all day," could entertain the thought of "hopefully find[ing] a way to get in the front seat as soon as possible."[151]

It wasn't just those who were destined to ride in the back of the Phantom that were put off by its two-seat configuration. Many front seaters worried about a new, snot-nosed, young lieutenant pilot-GIB trying to tell them where and how to fly. Even by 1972, Phantom GIBs were still encountering front seaters who had previously flown single-seat fighters and whose attitude was "they had done it all before," and therefore they didn't need a GIB. In the Phantom, though, they had to have one because many of the critical aircraft systems, including the inertial navigation system, could only be controlled from the rear seat. One solution was to simply use the GIB as an automaton to carry out the front seater's commands, and many GIBs reported receiving rather simple instructions from their front seater: "Shut up, go cold mike [turn off the radio intercom], and when I need you I'll tell you." Welch suggested that these front seaters saw the GIB as a threat to their "manhood." Another pilot remembered that "an awful lot of the guys in the front seat" showed no interest in learning about the radar or the GIB's tasks, and similarly exhibited no desire to share their piloting experience with their GIB. Thus, although the young pilots were supposedly put in the Phantom's back seat to receive "apprentice training" and learn how to be a better fighter pilot, "in practice," future Lieutenant General John Burns observed of his time in Vietnam, "it didn't work out that way."[152]

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[151] Meyer, "Phantom Over Tampa Bay"; Sokol, interview; Anderegg, interview, October 2, 2013; Hill, Oral History Interview, 20–22; Buhrow, Oral History Interview, September 28, 1967, 43–45; McCarthy, *Phantom Reflections*, 32–33; Scholin, "New Phlyers for the Phantom," 48. Wallace, on the other hand, actually opted for a right-seat in the C-141 over the back seat of an F-4, explaining that at the time he was "thinking about going to the airlines." After being in the C-141 for eighteen months and not getting the flying time he was once promised, Wallace said he "got bored … and was able to wrangle an F-100 assignment … to Southeast Asia." Wallace, interview.

[152] Welch, Oral History Interview, 87–88; Welch, interview, October 1, 2013; Anderegg, interview, October 2, 2013; Sokol, interview; Hendrickson, Oral History Interview, 61–62; Robbins, Oral History Interview, 106; McCarthy, *Phantom Reflections*, 154; Burns, Oral History Interview, June 5, 1984, 217–18. McCarthy remembered getting a "few orientation rides in the backseat to familiarize us [front seaters] with the systems, but I was not very knowledgeable about all their intricacies." Of course, there were exceptions. See, for example, accounts in: Hargrove, Oral History Interview, 29–36; Buhrow, Oral History Interview, September 28, 1967, 45; Skogerbee,

The tension within the cockpit was further exacerbated by the Air Force's decision to implement a "one-tour policy" for its combat aircrews. The policy reflected the service's desire to spread combat experience among its aircrews and knock down the castes that had developed within TAC, SAC, and ATC. However, as the war wore on, the supply of trained and experienced fighter pilots available to fill the front seat of the Phantom steadily dwindled. As it had once before in Korea, the Air Force began sending its non-fighter pilots, individuals who had spent years flying larger transports, bombers, or other training aircraft, to a brief training course and then off to war in the service's premier fighter. The effects were, in the words of one fighter pilot, "devastating," and the retrained pilots were "universally disrespected.... They were good guys ... but they could never catch up." Another pilot expressed a similar sentiment of the retrained pilots, noting that "[An] 80-hour training course ..., if they have no previous fighter time, fighter background, fighter tactics, is just not quite enough to bring them up to par." The net effect of the policy was that, according to one post-war Air Force analysis, the service was forced into "fighting seven one-year wars" while relying on a stream of replacement pilots of steadily decreasing skill "instead of one seven-year war" with increasingly combat-seasoned pilots.[153]

Whereas the Phantom front seaters became increasingly diversified during Rolling Thunder, the incoming GIBs continued to be pulled fresh from pilot training. Moreover, the future GIBs also continued to be skimmed from the top of their pilot training classes based

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Oral History Interview, 5. Anderegg remembers the GIBs having a "very ad-hoc, very informal group called the GIB Protective Association—the GPA. We got together a lot. And we talked about the front seaters, and who could do what well, and who couldn't do what so well, and what guys were like to fly with." Anderegg, interview, October 2, 2013.

[153] Anderegg, *Sierra Hotel*, 13–14; Michel, *Clashes*, 162–66; Andrews, "To Fly and Fight," 189–90; Olds, Corona Ace Oral History Interview, 79–82; Olds, *Fighter Pilot*, 245–46; Blesse, Corona Ace Oral History Interview, 24–30, 33–36; Welch, Oral History Interview, 40–41; Dilger, Oral History Interview, 6–7; Hannah, *Striving for Air Superiority*, 89. The service was concerned that with TAC crews flying repeated combat tours in Vietnam, an "irreversible gap" might emerge between TAC and SAC that could "fracture and compartment the Air Force." Anderegg declared the "one tour policy" concept "noble and well-intentioned, but its effect was devastating on to the combat capability of the tactical forces." Additionally, the notion of a "universally assignable pilot"—that any Air Force pilot could fly any Air Force aircraft with a bare minimum of training—reeked of "institutional arrogance." Michel attributed the decline in the performance of Air Force fighter pilots to the "one tour policy." He observed that from April 1965 through June 1967, about 65 percent of the Air Force's fighter pilots in Vietnam had backgrounds in TAC, and the service posted a three-to-one advantage over the MiGs in kill ratio. In contrast, from June 1967 through March 1968, less than 30 percent of Air Force combat pilots came from TAC, and the service's kill ratio dropped to 0.85:1. Much of the F-4 experience necessarily migrated to the Phantom training units as they tried to produce ever-increasing numbers of graduates. At its peak in mid-1967, almost every Phantom sortie flown over the US was a training sortie for someone preparing to go to Vietnam; only Eglin AFB was spared from becoming an F-4 training location.

on the understanding that they would one day become fighter pilots after their initial grooming assignment in the Phantom's back seat. This apprenticeship program was now, however, the responsibility of "temporary," cross-trained fighter pilots who had not made the initial fighter pilot cut. Riding in the back seat of a Phantom flown by a pilot whose flying skills were often judged to be less than his own, it was easy for a GIB to get depressed, especially when he "gets his everliving tail shot off continually and can do nothing about it."[154]

The situation was even more trying for those experienced GIBs who were nearing the end of their combat tour. They were usually paired with a "neophyte" front seater who, although technically in charge of the aircraft, possessed little practical knowledge of combat flying in Vietnam. For example, on Hill's seventieth combat sortie on December 16, 1967, he was paired with a front seater who had never flown a mission into North Vietnam. It ended up being Hill's last combat sortie; their Phantom was shot down by a MiG-21 that had snuck in behind them.[155] Sokol noted that toward the end of his combat tour, he had no intention of dying or becoming a POW because of his front seater's buffoonery, and he "wasn't afraid to take the airplane away from the guy [in the front seat]" to prevent that from occurring. Sokol joked that in the process he earned a reputation as "an asshole back seater."[156]

This was not exactly what the GIBs had signed up for when they were told they could be a fighter pilot in the US Air Force. Their pay-off was supposed to be a quick upgrade into the Phantom's front seat. Along those lines, in November 1967, Momyer directed his F-4 units in SEA to establish an in-house program "to upgrade highly qualified and experienced F-4 pilots to aircraft commander status as rapidly as combat commitments

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[154] Everest, Oral History Interview, 13; Buhrow, Oral History Interview, September 28, 1967, 43–45; Handley, *Nickel On The Grass*, 159n67; McCarthy, *Phantom Reflections*, 32–33.

[155] Skogerbee, Oral History Interview, 16; La Salle, "Project CORONA HARVEST End of Tour Report," 8–9; Doerty, "End of Tour Report," 3–4; Osborn, "End of Tour Report," 2; Hill, Oral History Interview, iv, 38–46; McCarthy, *Phantom Reflections*, 32–33. Of note, Hill spent the next five years languishing as a POW in NVN while his front seater, Major James Low, the same former ace-Lieutenant from the Korean War, opted for early release after only eight months—an act considered near-treason among the POWs.

[156] Sokol, interview. Sokol told of one occasion in which he was the GIB for a former T-37 pilot training instructor who became spatially disoriented during a night attack mission. When the front seater got confused and failed to pull up out of the dive bombing attack, Sokol took control and recovered the plane. Later, the front seater had the gall to tell Sokol that he "really knew what was going on" and didn't need the help. Two other front seaters also credit their GIB with saving their lives when they became disoriented: McCarthy, *Phantom Reflections*, 46–50; Handley, *Nickel On The Grass*, 33–36.

and the local environment permit." A few units such as those in the 12th TFW had already been conducting their own pilot upgrades, using it as a tool to maintain "morale and motivation of the squadron pilots." However, although the GIBs had extensive combat experience and plenty of time riding in the back seat, there were still significant differences that distinguished their tasks from those of the aircraft commander. The upgrading GIBs, Welch jibed, quickly learned that flying and dropping bombs "wasn't quite as easy as it looked" from the back. For example, the 8th TFW's upgrade program still consisted of at least twenty-eight sorties and consumed more than ten weeks.[157]

Those GIBs who were not selected to upgrade while in-theater were supposed to be first in line for the Phantom's front seat when they returned to the states. "This was the bill of goods … that [the Air Force] sold" them, one front seater noted. However, when the end of their combat tours came, most GIBs received assignments that kept them riding in the back. The simple fact was that there were only a handful of front seat Phantom assignments that weren't either in combat, which the GIBs were excluded from based on the "one tour policy," or devoted to training new aircraft commanders for combat, which required an already experienced aircraft commander. Of course, the GIBs could always transition to SAC or ATC to fill those aircraft cockpits that had been emptied by their pilots flooding into the Phantom, and one front seater remembered his GIB saying he'd do just that, "go to training command—any place—to get where he was going to fly the airplane rather than ride in the back seat." The other way for the GIBs to get around the shortage of front seats was to immediately re-up for a second combat tour. If they chose that option, the GIBs would travel home to the states for six to seven months for F-4 aircraft commander training before returning to a new Phantom unit in Vietnam. Many GIBs, stoked by "youthful feelings of

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[157] Momyer to 8 TFW, 12 TFW, and 366 TFW, "F-4 Pilot Upgrading"; *History of the 8th Tactical Fighter Wing, Oct - Dec 1967*, 1:11–13; Burns, Oral History Interview, June 5, 1984, 217–18; Diefendorf, "End of Tour Report," 5–6; Beisner, "End of Tour Report," 3; Welch, interview, October 1, 2013; La Salle, "Project CORONA HARVEST End of Tour Report," 8. Momyer's goal of upgrading three pilots per month proved overly ambitious. Burns noted that years earlier, TAC had a policy that required GIBs fly two sorties a month in the front seat, but after an aircraft accident, General Sweeney discontinued the program. Besiner noted that the 12th TFW upgrade program prior to August 1966 consisted of twenty-one sorties. Illustrating the fact that the former GIBs still had much to learn in the front seat, Cook recalled one mission when his upgrading front seater flew a bit too close to their target while trying to drop their bombs and physically "knocked off the roof and part of the second floor" of the target structure with their airplane. Cook, *Once a Fighter Pilot*, 159–61.

invulnerability" and the overriding desire to *fly* a fighter, chose that option. Sokol was one; Anderegg too.[158]

As former GIBs started populating the front seats of the Phantoms, the situation for the current GIBs improved slightly. Anderegg in particular remembered that "it was great when you flew with a former GIB" because they were often more forthcoming and willing to share the piloting tasks. Sokol likewise noted that "ex-back seat pilots treated back seat pilots different than ex-F-100 pilots treated back seaters." After he moved to the front seat, Sokol took pride in the fact that, as a former GIB, he could help "make the back seater a better back seater," coaching him on proper radar operation and mechanization.[159]

Nonetheless, the pilot-GIB program remained a subject of intense controversy throughout Rolling Thunder. Many front seaters complained that their GIBs were neglecting their back seat duties and, instead of concentrating on becoming proficient at operating the complex Phantom radar, were too focused on moving into the front seat. "The capability of the F-4 is being wasted by having a pilot in the back seat," one front seater complained after a mission. "[We] need a radar expert in the back seat. The pilot back seater's primary goal is to be upgraded to the front seat rather than master the radar."[160] In fact, most back seat pilots agreed. For example, one GIB reported after a mission, "A radar officer would be more interested in the back seat operations than a pilot would be."[161] Anderegg admitted that he "certainly was interested in getting into the front seat." But he also pointed out that he and the other GIBs were winged-pilots who had to pass *pilot* performance checkrides each year, not *navigator* or *bombardier* checkrides, and hence they had to "keep some kind of pilot

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[158] Buhrow, Oral History Interview, September 28, 1967, 44; McCarthy, *Phantom Reflections*, 108; Sokol, interview; Anderegg, interview, April 9, 2013; Anderegg, interview, October 2, 2013; Osborn, "End of Tour Report"; Burns, Oral History Interview, June 5, 1984, 217–18; Olds, Oral History Interview, n.d., 82. One commander worried that the Air Force would not properly shepherd the "F-4 back-seaters who upgraded to the front seat and a second SEA tour. These men are the ones we need—the ones who go to war when war happens not when its [*sic*] their turn." Versurah, "Project CORONA HARVEST End of Tour Report," 5.

[159] Anderegg, interview, April 9, 2013; Anderegg, interview, October 2, 2013; Sokol, interview.

[160] "Present [pilot] back seaters," another front seater complained after a mission, "spend too much time trying to get to the front seat, and not enough becoming truly proficient with the fire control system." Of course, the corollary was that many front seaters had no interest in learning about or understanding the operations of the radar. Anderegg, interview, October 2, 2013; Burns, Oral History Interview, June 5, 1984, 217. There were also different opinions; for example, one front seater preferred having a pilot in the back seat because a "pilot [in the backseat] knows what you are looking for in the front seat." Quoted in Attinello, *Air-to-Air Encounters in Southeast Asia: Account of F-4 and F-8 Events Prior to 1 March 1967*, 161, 204.

[161] Quoted in Attinello, *Air-to-Air Encounters in Southeast Asia: Account of F-4 and F-8 Events Prior to 1 March 1967*, 187.

proficiency." He too would hear his front seater occasionally complain, "You're spending too much time wanting to fly the airplane." But Anderegg would reply, "Well, that's what my paycheck gets written on. It doesn't get written on whether or not I can do an offset radar bombing run." The situation inevitably "caused friction."[162]

Beginning in late 1968, Air Force senior leaders made two decisions that dramatically altered the environment in the Phantom cockpit. The first was a decision to begin sending newly winged pilots directly to the Phantom's front seat. Around the same time, the Air Force also decided to adopt the Navy's RIO-concept to fill the Phantom's back seat. The Air Force's new GIB would be called a Weapons Systems Operator (WSO) and he would be culled from the ranks of trained navigators. The Air Force stopped short, however, of adopting the Navy's preferred divisions of cockpit tasks, in which the RIO had primary control over the aircraft (exercised through the pilot in the front seat) during the long-range intercept portion of the mission before the front seat pilot took over when he could see the target. The change in policy was generally well-received by the Phantom aircrews. One Phantom front seater wrote approvingly, "The WSO formed a team with the pilot, supporting rather than challenging. You got synergy rather than erosion.... It was a good solution. Not perfect, but much better than before."[163]

Prior to the shift, and probably to a certain extent afterwards, the GIBs' common joke was that flying in the two-seat Phantom was "like being married." Although the analogy was more often used to refer to the pattern of communication between the pilot and the GIB—knowing when to speak and when to be quiet—it's probably a fitting descriptor for the broader context.[164] Each pilot and his GIB brought a different set of experiences and expectations to the cockpit. While in some instances they were compatible, many times they were not. At least in the case of the two-pilot cockpit, it was also a forced marriage that neither participant was too keen on entering, which inevitably added to the tension. Plus, the

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[162] Anderegg, interview, October 2, 2013.

[163] Anderegg, *Sierra Hotel*, 40–41; Hendrickson, Oral History Interview, 99; Rasimus, *Palace Cobra*, 19; Welch, Oral History Interview, 89; Tuso, "Navigator's Log"; Pattillo, "End of Tour Report," 53. Anderegg notes that the decision to put new pilots straight into the Phantom's front seat was made "under pressure from the Department of Defense" based on McNamara's opinion that the Air Force was not suffering from a pilot shortage as it claimed. On the pros and cons of WSOs, see also Hendrickson, Oral History Interview, 14; Robbins, Oral History Interview, 106–8; Ritchie, Oral History Interview, 30–34. On the later professionalization of the WSO-GIB in the Phantom, see: Hendrickson, "GIB and ACM"; Larkins, "WSO in Air-to-Air"; Pratt, "GIB and the F-4."

[164] Anderegg, interview, October 2, 2013.

thought of "being married" to another man didn't exactly conform to the fighter pilot myth. Nonetheless, the two crewmembers had to work together if the Phantom was going to function properly; the engineers at McDonnell had hardwired the requirement for intra-cockpit collaboration into the Phantom's design. The Phantom crews' stateside training was supposed to have reinforced the imperative that they work together, but it obviously didn't always produce the desired behavior. It was unfortunate because once the Phantom encountered hostile MiGs over Vietnam, the pilot and GIB would also have their own human-machine issues to attend to in their individual cockpits.

Managing Modes in the Back Seat

One F-4C instructor counted "fifty-seven different combinations of weaponry and flying modes" available in the Phantom.[165] When the McDonnell engineers designed the Phantom and divvied up the crew tasks, they elected to vest the majority of the mode controls in the hands of the GIB. The arrangement made sense since the front seater was supposed to be focused on flying the aircraft. The engineers also included some provisions to help automate the information flow between the two Phantom crewmembers, most notably the repeater radar scope in the front cockpit. But, most information still needed to be communicated verbally using the Phantom's radio intercom. It wasn't expected to be a problem during a long-range intercept. In those situations, the information exchange usually followed a logical sequence and generally flowed from the back seat to the front seat as the GIB used his radar and "descriptive commentary" to guide the front seater, who also benefitted from access to the same radar image, into a position where he could look outside and visually detect the target. However, when the Phantoms started battling the nimble MiGs over North Vietnam in visual engagements, the flow of information was reversed. Now, if the Phantom's four Sparrow missiles were to be of any use, the front seater had to talk the GIB's radar onto the enemy target. The F-4C was not optimized for this type of engagement nor the pattern of communication it required.

The first issue of the Pacific Air Forces (PACAF) Tactics and Techniques Bulletin, released on May 4, 1965, offered initial guidance to the Phantom aircrews in anticipation of future air combat. For example, the bulletin noted that if the enemy target maneuvered "out

[165] Quoted in Scholin, "New Phlyers for the Phantom," 50.

of the gimbal limits" of the radar during a close-range engagement, then the GIB should "come right out of the scope and pick up the bogey visually," using "every available handhold" to contort his body as needed to keep sight. Assuming the GIB could see the bandit, which was not at all a surety due to the restricted vision out of the Phantom's rear cockpit, the GIB needed to anticipate when and where the enemy aircraft might reenter the radar scan pattern so that he could quickly get his head back into the scope and get a radar lock. To facilitate obtaining a speedy lock in the high-G, maneuvering environment, the bulletin suggested the GIB reconfigure the Phantom's radar to a "gyro out" mode.[166]

"Gyro out" operations became one of two preferred modes for locking close-range targets specified in the 8th TFW's *Tactical Doctrine* manuals. The critical step was the GIB reaching over to the left side of his cockpit to the auxiliary radar set control and switching the radar from "gyro nor[mal]" to "gyro out" (figure 4.17). In "gyro nor," the radar was space-stabilized, which meant that regardless of the attitude of the aircraft, the radar swept back and forth across the horizon. In "gyro out," the radar used the aircraft's attitude as the frame of reference and the radar antenna swept back and forth in line with the aircraft's wings (figure 4.17).[167] The GIB was also supposed to select a "10-mile" scope range, "wide" gate, clutter "override," and "1 bar" scan, all located on the primary radar set control, which was installed just aft of the auxiliary panel (figure 4.17). The 10-mile scope range made it easier for the GIB to see a nearby target that would otherwise be crowded in the bottom-half of the B-scope radar display. "Wide" gate told the Sparrow missiles to anticipate potentially significant changes in the target's closing velocity due to the abrupt maneuvering. Clutter "override" was selected to minimize the chance of the Phantom's radar losing lock

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[166] Aust, "PACAF Tactics/Techniques Program (Bulletin #1)," 1:1, 3–4. The PACAF tactics bulletin based its recommendations on a recently conducted Navy test of its F-4Bs in a close-range environment. The Navy's summary report, included in the bulletin, noted that the central question of the brief test was, "Can the F-4B, notwithstanding the fact that someone forget to put guns in it, be utilized as an air superiority fighter and how does it compare with other contemporary fighter [aircraft] in this role?" The Air Force would conduct its own similar evaluation later as part of the "Featherduster" program. Visibility out of the Phantom's cockpit was considered atrocious compared to the unrestricted, bubble canopy of the F-86. One Phantom pilot remarked, "Those fine folks in St. Louis built a great airplane, but obviously didn't think seeing out of it was a priority." Cook, *Once a Fighter Pilot*, 160; Burns, Oral History Interview, June 5, 1984, 175; Robbins, Oral History Interview, 108; Anderegg, *Sierra Hotel*, 11.

[167] Aust, "PACAF Tactics/Techniques Program (Bulletin #1)," 1:4; *8th TFW Tactical Doctrine*, March 1967, 82–84; *T.O. 1F-4C-2-19*, 2–22–26.The primary difference between the initial tactics bulletin and the 8th TFW's tactics manual was with regards to the preferred clutter setting on the radar set control panel. When in "gyro nor" mode, the radar used inputs from the aircraft's inertial navigation system to remain oriented with respect to the earth's horizon.

due to the target's maneuvers and its changing radar "reflectivity." Finally, selecting "1 bar" scan locked the radar antenna to a fixed, but adjustable, elevation setting; in "3 bar," the radar automatically shifted in elevation at the end of each horizontal sweep.[168]

The GIB still needed to adjust the antenna so that it was level with the Phantom's wings, which he did using the antenna elevation control wheel on the antenna control stick (figure 4.10). Theoretically, the GIB should have been able to simply set the antenna elevation strobe, displayed on the right-side of the radar scope, to the level, center-scribe position. However, the tactics manuals warned that the antenna elevation display was "a poor guide for actual antenna positioning" because frequent on-the-line maintenance of the radar usually led to antenna misalignment. The manuals therefore recommended that the GIB always check the elevation alignment of the radar at the start of the sortie so that he could correct for any errors when needed.[169]

Figure 4.17. F-4C Radar Set Control Panels (rear cockpit). The auxiliary radar set control was mounted forward of the larger, primary radar set control panel. (Source: *T.O. 1F-4C-2-19*, 2-22, 25)

Once configured properly, the "gyro out" scan pattern resembled a "fan" approximately eighty-two-mils high (4.8 degrees) that swept along the plane of the Phantom's wings sixty degrees to either side of the nose. The radar antenna completed each 120-degree sweep once every second. Since there were no visual indications of the radar settings available to the aircraft commander in the front seat, and since he was likely intently looking outside at the enemy target anyways, the GIB needed to verbally inform the pilot once the radar had been changed to the "gyro out" mode. The aircraft commander could then "effectively … control the radar antenna pattern with the stick…. By maneuvering the target into the 'fan' the aircraft commander is providing the pilot with a blip to 'lock-on.'" The manuals suggested that the aircraft commander still verbally inform his GIB of the

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[168] Aust, "PACAF Tactics/Techniques Program (Bulletin #1)," 1:4; *8th TFW Tactical Doctrine*, March 1967, 82–84; *T.O. 1F-4C-2-19*, 2–22–26.

[169] *8th TFW Tactical Doctrine*, March 1967, 82–84; *T.O. 1F-4C-2-19*, 2–22–26.

target's "relative position," which would allow the GIB to focus his attention on that sector of the radar scope and better distinguish between the actual target blip and any spurious radar returns.[170]

Once the target blip appeared on the radar scope, the GIB still needed to complete the lock on. Using the antenna control stick, the GIB maneuvered the radar acquisition symbol over the target blip and commanded automatic tracking. Since there was a high chance the lock might fail to resolve correctly, the GIB had to verify the radar target parameters. Assessing the target's Vc, as displayed by the gap in the range rate circle, was usually the fastest way to validate the lock. Once the radar lock had been verified, the GIB then had to reach over and switch the radar from "gyro out" back to "gyro nor" to avoid sending corrupt target information to the Sparrow missiles at launch. After all that, the GIB could finally announce over the radio intercom, "Good lock!", and the aircraft commander could get ready to squeeze the trigger. It is important to remember that this entire process would be occurring during an extremely turbulent, close-range dogfight characterized by abrupt turn reversals and high-G maneuvering.[171]

The Phantom aircrews had another close-range targeting option. "Boresight" was originally intended to provide a limited "auto-acquisition" capability for the aircraft commander in the front of the Phantom. If the GIB selected "BST" (boresight) on the radar set control panel in the rear cockpit, the radar antenna would immediately snap to the aircraft boreline (or at least that approximate position due to the potential misalignment of the antenna) and begin staring straight ahead. If the radar was also set to a ten-mile scope range, the aircraft commander could depress the auto-acquisition switch on his left throttle to command the radar to start scanning for targets dead ahead out to 20,000 feet and back again. The entire range scan took two seconds. If the radar detected a target, it was supposed to automatically lock on, but the aircrews discovered that the auto-acquisition system was at best unreliable. The boresight mode could also be used to launch a Sparrow missile without a radar lock, assuming the pilot was able to keep the enemy target directly in front of the

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[170] *8th TFW Tactical Doctrine*, March 1967, 82–84; *8th TFW Tactical Doctrine*, December 1967, 132. The December 1967 tactics manual noted that the front seater could "help accomplish a quicker lock-on by telling the pilot the range of the target and if the target will be coming from top to bottom of the scope or vice versa."

[171] *8th TFW Tactical Doctrine*, March 1967, 82–84.

Phantom and within the narrow, 4.8-degree spotlight view of the fixed radar antenna throughout the missile's time of flight. This too was judged to be unreliable.[172]

A better method of using the boresight mode was developed by the Navy and outlined in the May 1965 PACAF tactics bulletin and later 8th TFW tactics manuals. Olds and Clifton had used this modified boresight procedure to obtain the radar lock on their first MiG during Operation Bolo, and the crew in Mink 4 on July 10, 1965, had also tried to use the boresight mode before they realized that their radar had failed. Usually, the aircraft commander would tell his GIB that he was going to maneuver for a boresight lock, announcing "Go Boresight!" over the intercom. At that point, the GIB needed to confirm that the radar was configured to a ten-mile scope range, with "wide" gate and clutter "override" selected, and then rotate the radar mode knob on the radar set control panel from "RDR" to "BST." Then, as the aircraft commander aggressively maneuvered the Phantom to position the enemy target dead-ahead and within the small spotlight view of the radar, the GIB stared at the radar scope between his knees waiting for the target blip to appear. As with the "gyro out" mode, once the GIB saw the target blip, he needed to use the acquisition symbol to command automatic tracking. After checking the target's Vc to verify the lock, the GIB then needed to reach over and return the radar to its normal "RDR" operating mode. This step unlocked the radar antenna and allowed it to track the target over the full gimbal range of the antenna, freeing the pilot from having to keep the aircraft pointed at the target. The tactics manuals warned the GIB to be alert because it was common for the radar to break lock during this transition from boresight to normal radar mode. Once again, the GIB would announce the completion of the process by announcing "Good lock!" over the Phantom intercom. If time remained, the GIB might also call out the range to the target so that the front seater would know if he was in range to fire a Sparrow missile.[173]

In both the "gyro out" and "boresight" short-range scenarios, the key to successfully getting a radar lock and employing the Phantom's primary Sparrow armament was, according to Olds, "a bit of dexterity on the part of the youngster in the back seat." Olds

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[172] Aust, "PACAF Tactics/Techniques Program (Bulletin #1)," 1:4; Scott, *F-4C Fighter Screen and Escort*, 9; *T.O. 1F-4C-34-1-1*, 1–31; *T.O. 1F-4C-2-19*, 2–23; Michel, *Clashes*, 151–52.

[173] Asay, Covington, and Stone, *History of Operations BOLO*, 40; Attinello, *Air-to-Air Encounters in Southeast Asia: Account of F-4 and F-8 Events Prior to 1 March 1967*, 59; *8th TFW Tactical Doctrine*, March 1967, 80–82; Hargrove, Oral History Interview, 30–31.

forgot to mention the importance of a good communication channel that allowed the front seater and his GIB to coordinate their actions. While the switchology was cumbersome and inconvenient, the GIB could rehearse the movements and work on developing the necessary habitual response patterns. Unfortunately, a reliable communications channel was not so easily practiced and refined. As the 8th TFW's tactics manual noted, "communications between the aircraft commander and the pilot are difficult when engaged in combat due to the cluttered [radio] frequency," and the manual consequently warned the Phantom aircrews to be prepared for potential confusion and miscommunication when attempting a short-range lock.[174]

Had the Phantom crews normally flown together, it is possible that many of the communication difficulties experienced in the air, as well as the general tension within the cockpit, might have been mitigated. For example, senior officers usually flew with only a few GIBs, e.g. Olds and Clifton, which allowed the two officers to develop a rapport and better anticipate each other's actions. However, for the majority of flyers, the pairs of aircraft commanders and GIBs were often cobbled together each day as necessary to fill the flying schedule. Already immersed in a potentially tense cockpit environment, and with each aircraft commander possessing his own preference for "gyro out" or "boresight" mode, the GIB was often placed in the unenviable situation of never quite knowing what to expect and when. As one GIB lamented, "you get into a situation where it's react right now or get killed and you don't know exactly what to do, what this guy wants from you in the front seat." Another GIB complained after an April 1966 mission that he "was not contributing anything to the engagement" because he "did not know [the] next action planned by [the] front-seat pilot."[175]

The close-range dogfight scenario required the GIB to function essentially as an automaton that upon command could rapidly flip switches and rotate dials, thereby allowing the front seater to take partial control over the radar beam. Of course, the front seater still

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[174] Olds, Oral History Interview, July 12, 1967, 39–40; *8th TFW Tactical Doctrine*, March 1967, 80, 82. See also comments on the communications difficulties in Burns, Oral History Interview, June 5, 1984, 218; Attinello, *Air-to-Air Encounters in Southeast Asia: Account of F-4 and F-8 Events Prior to 1 March 1967*, 114–15, 134, 178, 204, 332.

[175] Anderegg, interview, October 2, 2013; Sokol, interview; Hendrickson, Oral History Interview, 41–42; Attinello, *Air-to-Air Encounters in Southeast Asia: Account of F-4 and F-8 Events Prior to 1 March 1967*, 134. Ritchie was a big proponent of formed crews; see Ritchie, Oral History Interview, 25–34; Ritchie, Corona Ace Oral History Interview, 34–36.

required the GIB to lock the target and verify its validity. But the GIB's procedures during the "gyro out" and "boresight" processes were fairly well specified. That was not true in the long-range environment, which continued to play a large role in Phantom operations over Vietnam even if it would not usually lead to an immediate missile launch due to the VID requirement. Phantom aircrews still used their radars to scan the airspace at long-range, hoping to detect any enemy aircraft and gain valuable situational awareness for the ensuing intercept and dogfight.[176] In this environment, the GIB possessed considerably more freedom when configuring and operating his radar.

Most Phantom aircrews appreciated the fact that "finding another aircraft with the F-4 radar was not a simple task." There were two critical elements that needed to be constantly refined by the GIB if the Phantom's radar was going to detect an enemy target at range. The first was the antenna's elevation angle. With the narrow, pencil-beam radar only being swept across the horizon in azimuth, the GIB had to steer the radar precisely in elevation. The 8th TFW's tactics manuals provided guidance for each GIB in a four-ship flight on how best to configure his aircraft's antenna elevation to maximize the entire formation's chances of detecting a target at any likely altitude. However, the guidance remained somewhat nebulous due to the lack of reliable antenna elevation cues within the Phantom cockpit. For example, the GIB in the flight leader's aircraft was instructed to set his antenna elevation using a one-bar scan on a fifty-mile scope and then adjust his antenna elevation so that "approximately ½-inch of ground return appears at the top of the scope." With the aircraft altitude above the ground constantly in flux due to the variations in terrain, which would also cause the ground return line to constantly shift up and down the scope, it was up to the GIB to determine how often to refine his antenna elevation placement.[177]

Even with a properly set antenna elevation angle, the radar would still miss a target if its gain was not adjusted properly. While the Phantom incorporated automatic gain control

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[176] Scott, *F-4C Fighter Screen and Escort*, 3, 9. For example, a later PACAF Tactics and Techniques Bulletin reminded Phantom aircrews that "maximum effort should be made to obtain long range radar contacts and establish an optimum attack position within the launch envelope for AIM-7 firing," even if "this ideal attack cannot be achieved in many cases and close-in fighting may become necessary." On the flexibility of the radar setup, the same bulletin noted that "the radar scope ranges used [in combat] vary with personal pilot preference."

[177] McCarthy, *Phantom Reflections*, 66; *8th TFW Tactical Doctrine*, March 1967, 75. The recommended steps for settings for Number 3's radar elevation were more cumbersome: "3-bar radar, 50-mile scope, adjusts the antenna to obtain ½-inch of ground return on the lowest sweep and selects 1-bar scan, automatically raising the antenna to the desired elevation."

into its radar circuitry during tracking operations, in search, gain adjustment was the responsibility of the GIB. He had two controls, "coarse" and "fine," both located on radar set control panel (figure 4.17). Sokol noted that there weren't any suggested settings for the gain, like "eight, or ten, or six, [it was] just a knob." Consequently, Sokol remembered that you simply "turned it until you saw something you liked." Since the radar return on the scope was a function of varying altitude, terrain, and atmospheric conditions, the GIB was constantly adjusting the gain throughout the flight.[178]

Moreover, the scope was never as clear as depicted in the flight manuals (figure 4.8). "You always had noise on the scope," Sokol recalled. "If you want to see a little airplane, then you had to turn the gain out. [But] turn it up too much, [and] then it kind of starts blossoming with all kinds of [stuff] on there. And there's nothing that filters out the ground sounds." Furthermore, the GIB was essentially looking for one "fuzzy blip" amidst a sea of other "fuzzy blips." As Welch described it, the GIB's job was to look at a screen full of "white dots" and "mentally integrate how are all those white dots behaving, because the one that's behaving differently is not the Earth. The one that's behaving differently is something moving over the Earth." Recognizing the difficulty of the GIBs' task, Welch commended them, "It was an art to picking an airplane out of all that noise."[179]

Thus, to be effective in the Phantom's back seat, the GIB needed to be able to read both his front seater's mind (for close-range engagements) and the figurative mind of the aircraft's radar (in the long-range environment).[180] The GIB processed both what he saw and heard, and what he didn't see and hear, to anticipate the requirements of his crewmember and the aircraft. For example, in the close-range environment, seeing the enemy aircraft appear off the wingline might suggest that a "gyro out" lock would be most efficient, whereas not seeing the enemy aircraft because he was under the Phantom's nose might be used as an indication to set up for a "boresight" lock. Similarly, in the long-range environment, the absence of a sufficient number of "fuzzy blips" might suggest that it was time to readjust the radar's gain, whereas too many "fuzzy blips" might indicate that the

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[178] *T.O. 1F-4C-34-1-1*, 1–30; Sokol, interview; Anderegg, interview, October 2, 2013.

[179] Sokol, interview; Welch, interview, October 1, 2013.

[180] Scholin, "New Phlyers for the Phantom," 50. One Phantom instructor cited by Scholin made note of the requirement for the GIB and his pilot to be able to "almost read each other's mind when they've got to work fast," but he failed to see the similar, figurative connection between the GIB and his radar.

antenna elevation angle had drifted too low toward the ground. While sometimes described as merely the front seaters' "hands and fingers back there," ready to throw switches and turn dials on command, the young pilot-GIBs certainly had the potential to play a greater role.[181] Whether or not they achieved that potential was a function of both the human interpersonal dynamics within the cockpit and their proficiency mastering the set of human-and-machine dynamics localized in the back seat.

Improvising in the Front Seat

The pilots in the front seat had their own set of unique concerns, not the least of which was simply flying the aircraft. Pilots' assessments of flying the F-4 Phantom vary. Some, like Bakke, considered the F-4 a "stable and honest aircraft." Burns labeled the F-4 "the most wonderful airplane I had flown," and another pilot claimed that the Phantom was "an extremely easy airplane to fly."[182] Sokol noted that the Phantom was so smooth that it could lull its pilot to sleep, a fact that was revealed to him one day on a cross-country mission over the United States.[183] Others, however, remembered that the F-4 could be a handful. It had its nasty "adverse yaw demon" that would suddenly appear at high AOA with the slightest misapplication of the flight controls. Anderegg, for example, recalled one "eye-watering" out-of-control situation in the Phantom that threw him so hard into the canopy rail that it snapped one of his pocketed pencils in half. The Phantom also exhibited a pronounced "Mach tuck" that occurred whenever the aircraft slowed from supersonic to subsonic speeds—the Phantom's stabilators would suddenly dig in at approximately 0.92 Mach and lurch the aircraft's nose down, potentially over-stressing the airframe.[184]

The apparent inconsistency in the pilots' assessments reveals the subtle shift in evolving conceptions of what *flying* a fighter entailed. "It's easy to fly," one pilot noted of the

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[181] Burns, Oral History Interview, June 5, 1984, 218.

[182] Bakke, Oral History Interview, 11; Burns, Oral History Interview, June 5, 1984, 175; Buhrow, Oral History Interview, April 11, 1968, 28–29; Olds, Oral History Interview, n.d., 77. Olds once remarked, "I can't remember a single pilot that flew the F-4 that doesn't love it."

[183] Sokol, interview. Sokol was in the back seat reading a magazine when he heard the "noise change." He looked outside to discover that they were in "some big-ass dive." He then asked the front seater "what the hell are you doing?" only to discover that "he was asleep."

[184] Anderegg, interview, October 2, 2013; Sokol, interview; Hendrickson, Oral History Interview, 40; Burns, Oral History Interview, June 5, 1984, 189–90. Hendrickson remarked that one of his duties as a GIB was to alert the pilot of the approaching "Mach tuck" so that he could reduce the pressure on the control stick and avoid over-stressing the aircraft.

F-4, "it's a little more difficult to fly well." As they would all soon discover, it was even more difficult to fly it well in combat. A seminal shift in fighter aviation was transpiring, for in the past, *flying* a fighter was generally synonymous with *employing* a fighter. Do the first well and the other naturally followed. Now, the two concepts were beginning to diverge. Welch reflected on the distinction, noting that in his F-84, "The things that allowed you to succeed in the cockpit were … instinctive…. It was all about flying the airplane." In contrast, when he began flying the F-4, Welch discovered that he had to concentrate on developing his "ability to operate the systems in the airplane…. You began to move from [flying the airplane] to being a systems operator."[185]

The dizzying array of switches in the front cockpit was one manifestation of the shift. While the McDonnell engineers had placed most of the mode controls in the back seat of the Phantom, the front cockpit still retained its fair share of cumbersome switches and dials. Burns, like others, complained of "too many switches" arranged in a "terrible" layout. Compounding matters, once engaged in combat when "there was so little time to get all [the necessary switchology] done."[186] Consequently, like the GIB, the pilot in the front seat had to spend a fair amount of time getting acquainted with and rehearsing the intricate switchology.

Perhaps the most notorious switch in the Phantom's front cockpit was located on the missile control panel, which was located just above the pilot's left knee (bottom left of figure 4.18).[187] The three-position RADAR—HEAT—HEAT REJECT switch

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[185] Buhrow, Oral History Interview, April 11, 1968, 28–29; Welch, interview, October 1, 2013.

[186] Burns, Oral History Interview, June 5, 1984, 169. For a contrarian opinion, see Olds, Oral History Interview, n.d., 77–78.

[187] The RADAR switch on the far left "tuned" the Phantom's four Sparrow missiles to the aircraft's radar frequency (in its middle, STBY position) and activated the special continuous wave radar illuminator (in its top, PWR ON position) to help illuminate the enemy target so that the Sparrow missiles could guide while in flight. While the switch itself simple, the 8th TFW developed rather a complex procedure for using it. After starting the engines, the pilot needed to select STBY to allow the continuous wave (CW) transmitter to warm up. During taxi, the pilot was supposed to pull the "forward missile bay firing control" circuit breaker and momentarily select PWR ON to check if the Sparrow missiles would tune properly. After take-off, the pilot was again supposed to select PWR ON for at least five minutes to prevent a "false tune" before returning the switch once gain to STBY. At that point, he could reset the firing control circuit breaker. Then, if the pilot was "flying in areas of high MIG threat," he was supposed to turn the CW switch back to its PWR ON position for the remainder of the flight "to prevent the possibility of the missiles de-tuning." *T.O. 1F-4C-34-1-1*, 1–19; *8th TFW Tactical Doctrine*, March 1967, 60.

The far right "interlock" (INTLK) switch was also used for the Sparrow missiles: with interlocks IN, the pilot was prevented from launching an AIM-7 if the Phantom's fire control system judged the aircraft to not be in an acceptable firing position, e.g. if the radar range to the target was not within the computed range of the missile

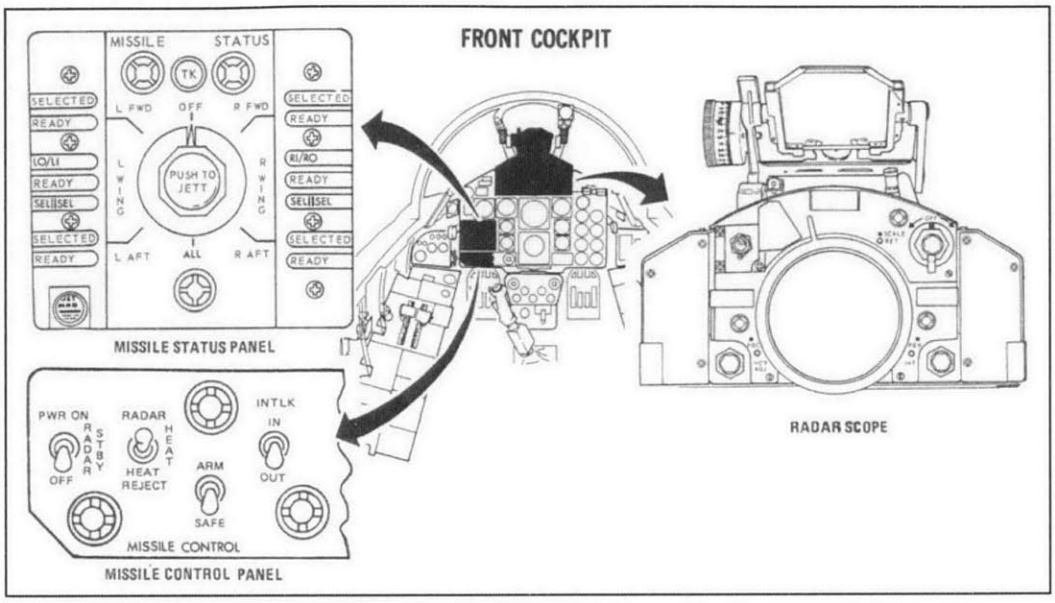

Figure 4.18. F-4C Air-to-Air Missile Controls (front cockpit).
(Source: *T.O. 1F-4C-34-1-1*, 1-19)

was itself not terribly complex. The top RADAR position selected a radar-guided Sparrow missile for launch; the middle HEAT position selected an IR-guided Sidewinder for firing; and the bottom spring-loaded HEAT REJECT position cycled through the on-board Sidewinder missiles to select the missile that would be fired next.[188] In combat, though, operating the missile select switch proved problematic. For example, during an engagement on April 23, 1966, a flight of four F-4Cs engaged four MiG-17s. After maneuvering behind one of the MiGs, one of the Phantom pilots decided he was in an optimum position to use a Sidewinder missile, but when he tried to lean forward to switch from RADAR to HEAT, he couldn't; his shoulder harness had locked. "I had difficulty releasing the inertial lock so I could reach the panel and change the switch," he explained after the mission. "Since the MiG was starting to evade, I elected to remain in the radar position and fire another AIM-7D Sparrow." Fortunately for him, the radar-guided missile worked and the enemy MiG was

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(between Ra and Rmin) and/or if the AIM dot was not within the Allowable Steering Error circle on the radar display. The 8th TFW tactics manual specified times to switch between interlocks IN and OUT. The interlock switch had no effect on Sidewinder missile launches. *T.O. 1F-4C-34-1-1*, 1–20, 1–34; *8th TFW Tactical Doctrine*, March 1967, 80–81, 88–90.

The ARM—SAFE switch in the center-right of the panel activated the firing circuits for the Phantom's air-to-air weapons.

[188] *T.O. 1F-4C-34-1-1*, 1–20, 1–37–38; *8th TFW Tactical Doctrine*, March 1967, 61. The pilot could not control the firing sequence of the Sparrow missiles.

last seen in a "near vertical dive" while "trailing thick grey and white smoke." It was the Air Force's first victory with the Sparrow.[189]

Assuming they could reach it, many pilots complained of having to fumble around feeling for the nondescript missile select switch. When engaged in a tight dogfight, diverting their eyes to look inside the cockpit at the switch, even momentarily, could cause the pilot to lose track of the enemy bandit. One expedient solution, Anderegg and Sokol both recalled, was for the pilot to fit a self-procured, two-inch-long piece of plastic tubing around the switch. That way, the pilots could blindly swat at the switch—up or down—to change between missile types. The pilots also started placing their worst Sidewinder, the one with the weakest tone, at the front of firing sequence; that way, when they slapped the missile select switch down to the bottom position during battle, the bad missile would be shuffled to the back. Regrettably, the difficulties the pilots encountered with the missile select switch were not unique; Anderegg noted that "several other cockpit switches were just as hard to manage."[190]

On top of managing the multitude of misplaced and poorly designed switches, the front seat pilots also had to become adept at properly estimating the different missiles' proper launch parameters. In the case of a Sparrow, assuming their GIB had managed to get a radar lock, there were several cues displayed on the radar scope intended to help the pilot judge the Sparrow's capability. These included the Ra and Rmin range strobes and the AIM dot. However, none of the cues were particularly effective in the skies over North Vietnam, because they assumed a non-maneuvering, 1-G target, something the wily MiGs were not.[191]

Like their predecessors, the Phantom pilots therefore needed to rely on intuition and experience when deciding when to use their weapons. They also had to contend with the uncertainty and excitement of the battle and the prospect of earning a kill. As one senior Air Force officer noted, "The desire to kill a MiG when you are close to him pushes the patience to wait for the ideal condition or to shoot on the chance you will never reach the ideal conditions." Plus, even when launched under what was assumed to be ideal conditions, a kill was never guaranteed. Based on the Sparrow's poor reliability, pilots were told to always fire

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[189] Attinello, *Air-to-Air Encounters in Southeast Asia: Account of F-4 and F-8 Events Prior to 1 March 1967*, 141–44.

[190] Anderegg, *Sierra Hotel*, 12; Sokol, interview; *8th TFW Tactical Doctrine*, March 1967, 61.

[191] Scott, *F-4C Fighter Screen and Escort*, 10; *T.O. 1F-4C-34-1-1*, 1–33.

two in an effort to increase the collective probability of a kill. But, even that might not help because as Olds noted, an alert MiG-17 could "literally out turn a Sparrow."[192]

The Sidewinder with its restricted firing envelope was even more difficult to employ properly. First, the pilot had to maneuver into the small thirty-degree cone at the aft end of the target. The cone, however, was not static; it maneuvered in a manner similar to the aircraft. For example, if the enemy was turning, then the cone followed his flight path, much like a streamer, which the Phantom pilot needed to visualize and then fly to a position on it.[193] Second, the Phantom pilot had to cue his Sidewinder missile to the target and ensure that it was tracking properly. The pilot accomplished this step by turning the Phantom to point at the enemy target and then listening, assuming that HEAT was selected with the missile select switch, for an audible "growl" in his headset. Unfortunately, picking out the "growl" among the cacophony of inter-flight radio communications and intra-aircraft intercom transmissions could be problematic. Moreover, the "growl" only indicated that the Sidewinder had found a heat source, not necessarily the correct one; over the course of the war, several Sidewinder missiles were launched at the sun. Finally, the pilot also had to make sure that his Phantom was at less than 2-Gs when he launched the Sidewinder or the missile's guidance gyros would tumble during launch, causing the missile to veer off course. But, reducing the back stick pressure to reduce the aircraft G-load so that the missile could be launched usually caused the Phantom to quickly exit the necessary thirty-degree firing cone. Therefore, as with the Sparrow, pilot experience and intuition played a vital role in deciding when to fire a Sidewinder and when to wait for a better opportunity.[194]

Additionally, the kinematics of both missiles varied based on the altitude, airspeed, and flight path of both Phantom and target. For example, at lower altitudes and against targets with higher crossing angles, the missiles' performance was significantly reduced. The pilot had to make these adjustments in the air, and they weren't necessarily easy to compute.

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[192] Scott, *F-4C Fighter Screen and Escort*, 10; Olds, Oral History Interview, July 12, 1967, 37; Blood, "End of Tour Report," 89; Attinello, *Air-to-Air Encounters in Southeast Asia: Account of F-4 and F-8 Events Prior to 1 March 1967*, 161. One Phantom pilot complained that "having to fight with two missile envelopes (Sidewinder and Sparrow) complicates the fighter pilot's problem."

[193] Boyd, "Aerial Attack Study." Boyd noted that "when employing [an] AIM-9B against a maneuvering target, the cone not only diminishes in size, it also changes in shape." On Boyd's "Aerial Attack Study," see Hammond, *Mind of War*, 46–48.

[194] Michel, *Clashes*, 43; Dilger, Oral History Interview, 25–26; Kirk, Oral History Interview, 3; Olds, Oral History Interview, July 12, 1967, 37–42; Olds, Oral History Interview, n.d., 69–70, 72–73; *8th TFW Tactical Doctrine*, March 1967, 84–88.

For example, the 8th TFW's tactics manual reminded pilots that the Sidewinder's minimum range would increase or decrease at a rate of 300 feet for every 0.1 Mach difference in Vc between the target and the Phantom; and its maximum range would "increase by 2,000 [feet] and the [acceptable] angle-off by 5° for each 10,000 [feet] of altitude." Further complicating matters, if the pilot was trying to employ a Sidewinder, he usually lacked a radar range source, so the tactics manual suggested he compare the size of the MiG's wingspan to the two-mil pipper displayed in the F-4's optical sight. Air Force pilots had resorted to stadiametric ranging, the original "bugaboo" of aerial weapons employment, for their advanced missiles.[195]

Furthermore, by mid-1966, the MiG pilots were routinely exploiting the American missiles' approximately half-mile minimum range, knowing that if they stayed close to the Phantom, the Phantom crews could not shoot them down. The close combat also provided the MiGs with an offensive advantage due to their cannon armament.[196] Already dangerously close to being mere missile managers, the Phantom pilots were now becoming borderline ineffective ones at that. In mid-1967, though, a cobbled-together innovation developed at DaNang AB under the purview of Korean War double-ace Blesse provided both a temporary solution to the Phantom's armament woes and a much-needed psychological boost to its missile manager-pilots.

The Phantom aircrews had been using the SUU-16 external, 20-mm gun pod—their "pistols"—since the 45th TFS's first deployment to Ubon RTAFB in mid-1965 (figure 4.19). However, the SUU-16 had always been restricted to air-to-ground strafing. The initial testing of the pod that summer had noted that, because the F-4C did not possess a lead-computing gunsight, the gun pod offered only a "limited" capability in an air-to-air environment.[197] The SUU-16's high drag, a function of the exposed gun barrels at its front end, and the fact that it occupied the space normally reserved for the Phantom's large, 600-gallon external fuel tank, which was vital during the long-distance missions into RP VI, left the majority of

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[195] *8th TFW Tactical Doctrine*, March 1967, 84–90; Greene to Commanding General, Continental Air Command, January 31, 1950.

[196] Michel, *Clashes*, 105–6; Blesse, *Check Six*, 121.

[197] Mehserle, *Capability of the F-4C Aircraft/SUU-16/A Gun Pod*, 35–36; *F-4C/SUU-16A*, 1; Alden to 9 AF, "TACOP Final Report for 45 TFS"; Cook, *Once a Fighter Pilot*, 145. TAC's November 1966 test was more pessimistic, declaring the SUU-16 "tactically unsatisfactory" for use in "an air-to-air role." Cook noted that they called their SUU-16s their "pistols."

Phantom pilots unenthused about the idea of carrying the gun into a battle against the nimble MiGs.[198]

Figure 4.19. SUU-16/A External 20-mm Gun Pod.
The small ram-air turbine that the airman is working on deployed in-flight to provide power for the gun. (Source: USAF)

Blesse was undeterred. Having just spent a year studying at National War College followed by an abbreviated F-4 checkout at MacDill, Blesse arrived at DaNang in early 1967 to serve as the 366th TFW's Deputy Commander for Operations. A long-time proponent of the combat value of an air-to-air gun, Blesse was well aware of the Phantom missiles' lackluster performance. With MiG activity on the rise and the 366th's pilots assuming a larger share of the MiG CAP missions, Blesse was determined to find a way to use the SUU-16 in air-to-air combat. One pilot remembered Blesse telling him, "All I want to do is get a gun on there.... I don't care if we have to ... wire a ... 38-caliber pistol with a string to it, that's what we'll need against those MiGs!"[199]

The Phantom pilots in the 366th responded to Blesse's call. They quickly determined that the lack of lead-computing gunsight in the F-4C, although certainly not ideal, was not the major stumbling block. Fighter pilots in the earlier World Wars had used fixed gunsights, and American pilots over Vietnam could do the same, especially since they would no longer be using a pair of .30-caliber machine guns but rather a six-barrel Gatling gun capable of firing nearly 6,000 rounds a minute (the SUU-16 only carried about twelve-seconds worth of ammunition). The Phantom pilots figured that if they could get the MiG to fly through their "very concentrated burst," the "rounds [would] stitch through the wing or cockpit area like a sewing machine." They therefore planned to simply over-lead the target, placing their fixed sight "about twice as far [forward] as you thought necessary" before slowly walking it back

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[198] Bakke, interview. Bakke remembered a demonstration flight for "a civilian official of influence" that was intended to impress on him the undesirability of the external gun because of its excess drag and maneuvering limitations. The Air Force was pushing hard at this point to gain approval for the F-4E with its internal gun.

[199] Blesse, *Check Six*, 113–14, 119–20; Bakke, interview; Blesse, Corona Ace Oral History Interview, 59–60. Blesse viewed missiles and guns as complementary weapons, but he was unable to persuade "the missile people" that occupied the Pentagon in the late 1950s. One was Momyer, who reportedly told Blesse, "You goddamn fighter pilots are all alike. You get a couple of kills with a gun and you think the gun is going to be here forever. Why can't you look into the future and see that the missile is here and the guns are out?"

towards the enemy MiG, all the while spraying bullets out in front. The procedure was imprecise and inefficient, but, as Olds noted, "all you need is a few of them to hit and down he goes."[200]

The primary technical roadblock was instead related to the aircraft's configuration when carrying the SUU-16. To use the SUU-16 in RP VI, the pilots first needed to rewire their aircraft so that they could carry their ECM pod on their inboard wing pylon. At present, the jamming pods could only be used when outfitted to an outboard wing pylon. If the pilots could figure out a way to shift the ECM pod to the inboard station, they could carry an external fuel tank on their right outer wing pylon to compensate for the 600-gallons of fuel lost when the SUU-16 replaced the centerline external fuel tank. Blesse's team at DaNang developed a special wiring harness that effected the necessary changes in the aircraft's configuration.[201]

Encouraged by their early progress with the modifications, Blesse sent a message on May 5, 1967, to his commander at Seventh Air Force, Momyer. In it, Blesse reiterated the motivation for his experiment and asked Momyer for his permission to complete the planned installation. "This Wing has lost minimum seven kills in the past ten days because of a lack of kill capability [against targets] below 2,000 feet altitude and inside 2,500 feet range," Blesse explained. He also called attention to the irony of the situation: "It is interesting to note we are dusting off deflection shooting info published early WWII and Korea for our Mach 2 fighters." Momyer acceded to Blesse's request and a week later, the first gun-equipped Phantoms thundered off from DaNang's runway.[202]

Two days later on May 14, 1967, the pilots in Speedo flight downed two MiG-17s with their SUU-16s. The victorious pilots were ecstatic and extolled the virtues of the gun. Hargrove explained how he was able to begin his attack on the MiG from only 2,000 feet away, closing in to "cut him in half with the gun.... Without the gun ... I don't see how I possibly could have gotten a MiG." Another pilot agreed, stating that his kill "with the gun

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[200] Blesse, *Check Six*, 121; Olds, Oral History Interview, July 12, 1967, 42. Blesse lamented, "After the extremely capable A-1C radar computing gunsight we used 15 years earlier in Korea, it was difficult to understand how we could find ourselves in this situation."

[201] 366 TFW to 7 AF, "C10697"; 366 TFW to 7 AF, "AFR 57-4 Mod I Proposal"; Bakke, interview; *History of the 390th Tactical Fighter Squadron, May 1967*; Bolt, Oral History Interview, 195–97; Olds, Oral History Interview, July 12, 1967, 42–44; Olds, Oral History Interview, n.d., 76. Olds failed to attribute credit for the modification to the 366th TFW. See also Fino, "Breaking the Trance."

[202] 366 TFW to 7 AF, "C10697"; Blesse, *Check Six*, 123; Michel, *Clashes*, 104.

... could not have been made with a missile." The 366th's official report of the engagement noted: "All members of SPEEDO [flight] spoke praise for the SUU-16 gunnery system. We think the results speak for themselves." By the end of the month, Olds's pilots in the 8th TFW at Ubon were also carrying an external gun pod on their Phantoms. They claimed their first gun kill on October 24, 1967.[203]

A few months after the 366th's first gun victories, Blesse was summoned to the Pentagon to meet with McNamara. Responding to one of the Secretary's questions, Blesse declared the gun "one of our most versatile and effective weapons, air-to-ground and air-to-air, in spite of the lack of a computing sight capability." That same month, Olds characterized the gun as "an outstanding development.... I gnash my teeth in rage to think how much better this wing could have done had we acquired a gun-carrying capability earlier." Other pilots like Kirk, who claimed the 8th TFW's first victory with the gun and who Olds once described as "a hell of a good stick," similarly praised the gun pod as "the finest thing that was ever invented." Flying in a later F-4E, one WSO-GIB remarked that after the experience of "trying to fire three AIM-7s, having one of them blow up in the air, having the other one go ballistic and one not even come off the airplane," the nose gun was universally recognized as "something you could depend on."[204]

The praise for the gun, however, overlooked an important fact; while the gun's mechanical performance may have been more consistent than the Phantom's missiles, it wasn't necessarily easier to employ. Dilger, one of the initial cadre in the 366th TFW that worked on the gun program, noted that one of the wing's pilots had "never fired a gun before in his life," and when he tried to do so in combat, "his tactics were so gross that you couldn't expect the gun to have done him a good job."[205] Olds too, despite his enthusiastic appraisal of the gun in his July 1967 interview, harbored reservations. At one point, Olds

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[203] 366 TFW to NMCC et al., "Change 1 to 366TFW OPREP-3, Number 010, FASTEL 443"; 366 TFW to NMCC et al., "Change 1 to 366TFW OPREP-3 Number 011, FASTEL 442"; Hargrove, Oral History Interview, 22–23; Futrell et al., *Aces and Aerial Victories*, 55–58, 67–68; Attinello, *Air-to-Air Encounters in Southeast Asia: Events from 1 March 1967 to 1 August 1967*, 284–89.

[204] 366 TACFTRWG to CSAF, "Presentation to Sec Def"; Olds, Oral History Interview, July 12, 1967, 42–43; Kirk, Oral History Interview, 6–7; Olds, Corona Ace Oral History Interview, 25; Hendrickson, Oral History Interview, 50. Kirk noted: "Eventually we're going to have the E-model airplanes with the internal gun. That's the answer.... I think the Air Force has learned its lesson. We'll never build another fighter without an internal gun. I'm convinced of that, or at least I hope to G-- we don't." See also Payne, "Project CORONA HARVEST End of Tour Report," 4–5.

[205] Dilger, Oral History Interview, 11–13.

explained, "I had no intention of giving my young pilots the temptation to go charging off to engage MiG-17s with a gun. They would have been eaten alive." Olds further expounded on his concerns in his memoir, "We needed a gun, no doubt about it, but we needed pilots trained to use them even more."[206]

In the end, missiles remained the dominant means to score an aerial victory. Over the course of the Vietnam War, the gun on the Phantom (F-4C/D/E) only accounted for 15½ of the 108 enemy MiGs claimed by the Phantom aircrews. There were another five MiGs that were downed due to "maneuvering tactics," but the rest were all shot down by missiles.[207] The tallies illustrate the utility of the gun, especially in light of the pilots' claims that many of the kills with the gun would have been unattainable with the Phantom's missiles, but the pilots' zest for the once-deemed-antiquated gun was still wildly out of proportion to its actual combat results.

For the pilots, the significance of possessing a gun extended into the psychological realm. The gun did not rely on electronic black boxes and mysterious "beeps and squeaks" that the pilot had no control over. Nor did it rely on a GIB; most of the time the pilot in the back seat couldn't even see the results of the gun attack due to his restricted forward visibility. Rather, in the words of Burns, the beauty of the gun was that the pilots could now simply "stick [it] in the guy's ear. There is no countermeasure for that." Bugos therefore concluded that the addition of the gun to the Phantom was "a powerful ideological statement that Air Force pilots were less missile system managers than gunfighters, capable of dogfighting and strafing ground units like their predecessors." In fact, the members of the 366th TFW had anointed themselves with a nickname based on their prowess with the SUU-16. They weren't missilemen. They were "The Gunfighters."[208]

Actually, they were neither. Like the plastic tubing covering their missile select switch or their SUU-16 gun pod, the Phantom pilots were an improvisation—a cobbling together of the procedures-driven world of complex radars and missiles and the seat-of-the-pants

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[206] Olds's revised assessment of the gun and his stated rationale are quoted in Davies, *USAF F-4 Phantom II MiG Killers, 1965-68*, 31. See also Olds, *Fighter Pilot*, 317; Olds, Oral History Interview, n.d., 76–77; Blesse, *Check Six*, 123, 125. Indicative of Olds's initial concerns, Blesse remembered that when he was pitching his SUU-16 plan to General Momyer, Olds happened to be in the room. When Momyer asked for Olds's appraisal of the idea, Olds apparently said, "General, I wouldn't touch that with a ten-foot pole!"

[207] Futrell et al., *Aces and Aerial Victories*, 157. An F-105F and an F-4D shared credit for a MiG kill; hence, the ½ victory credit in the tally.

[208] Bugos, *Engineering the F-4*, 159; Blesse, *Check Six*, 126.

flying world central to the myth of the gun-slinging fighter pilot. Consequently, the reintroduction of the gun and the corresponding embrace of the proper fighter pilot image did not alleviate the demands on the pilot to study and learn their intricate systems, but it did acknowledge the flexibility that the pilots possessed when developing their tactics to use that technology. Olds took notice of the subtle shift taking place in the front cockpit: "My point to the guys was you never stop learning, you learn, learn, learn, learn, learn all the time [...] then maybe you live."[209]

Tensions Between Cockpits

As the Phantom aircrews struggled to resolve the tensions within their cockpits, both interpersonal and human-machine, tension also erupted within the F-4C community over how best to employ a formation of Phantoms in combat and the corresponding responsibilities of the flight members. Often instructed by Korean War veterans according to Blesse's "No Guts, No Glory," the Phantom aircrews entered Vietnam flying a Korean-era formation optimized for combat between gun-only-armed jets. Serious deficiencies soon emerged. As one Phantom pilot recalled, "We weren't trained in the right tactics or how to employ [the F-4] in an optimum fashion.... We just went over [to Vietnam] and freelanced it." However, despite several proposed alternative formations, most Air Force Phantoms for the duration of the Vietnam War continued to fly the same obsolescent F-86 Sabre formation. In answering why, it is important to understand that, like in Korea, the combat formation did not just serve a tactical purpose; it also possessed cultural significance to the fighter pilots, especially the role of the subservient, junior wingman within the formation.[210]

When the 45th TFS began flying its first missions over Vietnam in mid-1965, it used the standard "defensive spread," four-aircraft formation known as "fluid four."[211] While the spacing was wider than that used by the F-86 Sabres in Korea (figure 3.19), and would

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[209] Olds, Oral History Interview, n.d., 24. Suspension points in original. Olds was specifically referring to his unit's practice of using the last fifteen minutes of each flight to rehearse the various types of tactics that they needed to be proficient in.

[210] Bedke, Oral History Interview; Anderegg, *Sierra Hotel*, 20–21; Anderegg, interview, October 2, 2013; Wallace, interview; *F-4C Air Combat Tactics*, Supplement No. 1; Michel, *Clashes*, 169–72. Bedke explained, "We had been using old equipment; we had been using tactics that were acceptable with that equipment; and we just didn't have the foresight to look ahead."

[211] Alden to 9 AF, "TACOP Final Report for 45 TFS," 5. The 45th TFS initially had the two elements fly line-abreast at 6,000-feet distance. The wingmen were instructed to fly 1,500 to 2,000-feet away from their respective leader, slightly higher and at least ten-degrees back from the line-abreast position.

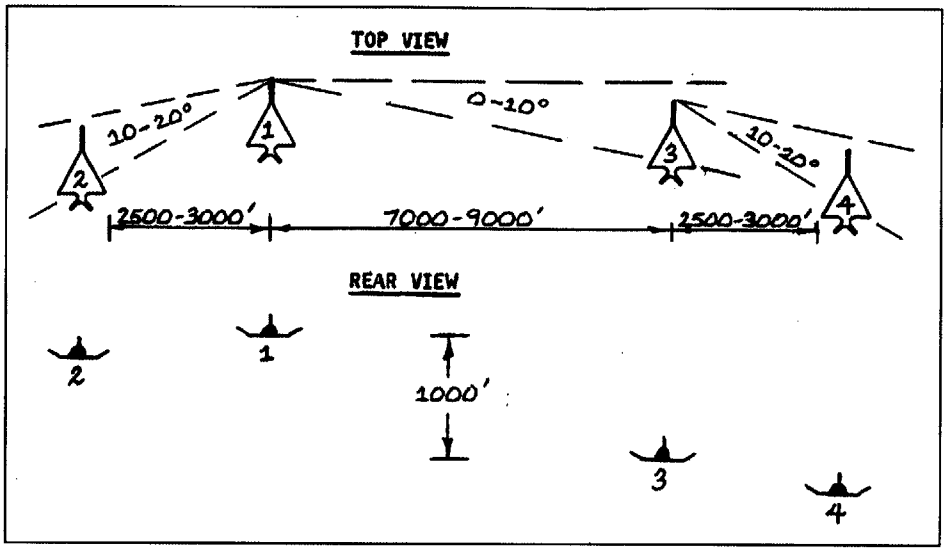

Figure 4.20. F-4C Fluid Four Formation.
(Source: *8th TFW Tactical Doctrine*, Mar 1967, 74)

increase slightly over the course of the war so as to provide additional room for the Phantoms to maneuver, the geometry among the aircraft had not changed. The two Phantom elements were to be nearly line-abreast, split by 7,000 to 9,000 feet, according to the March 1967 edition of the 8th TFW's *Tactical Doctrine*. The wingmen were supposed to fly closer, slightly aft, and slightly below their leaders, between 2,500 and 3,000 feet back (figure 4.20). The arrangement reflected the unchanged flight member responsibilities: with the wingman tucked in close to his leader, the junior pilot was in an optimum position to screen the more experienced pilot's vulnerable six o'clock, freeing the leader to concentrate on his attack against the enemy. In fact, if the flight came "under attack" or was "maneuvering to attack," the wingman was supposed to drop even farther aft into a sixty- to ninety-degree cone behind the leader, spaced 1,000 to 1,500 feet back—a position known as "fighting wing" (figure 4.21). Intended to make it easier for the wingman to perform his primary duty of protecting his leader, many pilots referred to the position as "'welded wing' because the wingman was there to stay, no matter what happened." As before, the flight lead was the designated "shooter"; the element lead, the "secondary shooter"; and the wingmen were the "lookers."[212]

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[212] *8th TFW Tactical Doctrine*, March 1967, 72–77; *8th TFW Tactical Doctrine*, December 1967, 119–24; Michel, *Clashes*, 170–72; McCarthy, *Phantom Reflections*, 67; Burns, Oral History Interview, June 5, 1984, 256–58; Anderegg, *Sierra Hotel*, 20–21; Anderegg, interview, April 9, 2013; Anderegg, interview, October 2, 2013; Sokol, interview. In the December 1967 version of the 8th's tactics manual, the "fighting wing" position was refined to be only a sixty-degree cone, and the altitude difference between the two Phantom elements in "fluid four" was increased from 1,000 feet to between 2,000 and 3,000 feet.

Unfortunately for the wingmen, the "fluid four" and "welded wing" concept may have worked well when the enemy had to close to within 1,000 feet to fire its air-to-air cannons, but it didn't work so well when facing a hard-to-see MiG-21 capable of launching an AA-2 Atoll from more than a mile away. Moreover, the Sabre pilots had enjoyed the benefit of a large bubble canopy that allowed them to see nearly all the way behind them, but the F-4's faired cockpit design severely restricted the Phantom aircrew's visibility aft of their aircraft's wingline. In this environment, who was going to protect the wingman and clear his six o'clock position? Additionally, with the extreme power of the Phantom and its ability to rapidly maneuver in the vertical, the welded wingman was always at risk of being thrown from the formation, or worse, colliding with his leader. Many wingmen complained that, although they were in fighting wing ostensibly to observe the fight and help their leader, they "never saw anything of the 'fight' because they were just trying to 'hang on.'" Sokol noted that the formation might have been "a great plan in Korea or somewhere, but [it] was not exactly optimum for the war we were fighting in Vietnam.... All you are out there are shock absorbers to suck up missiles."[213]

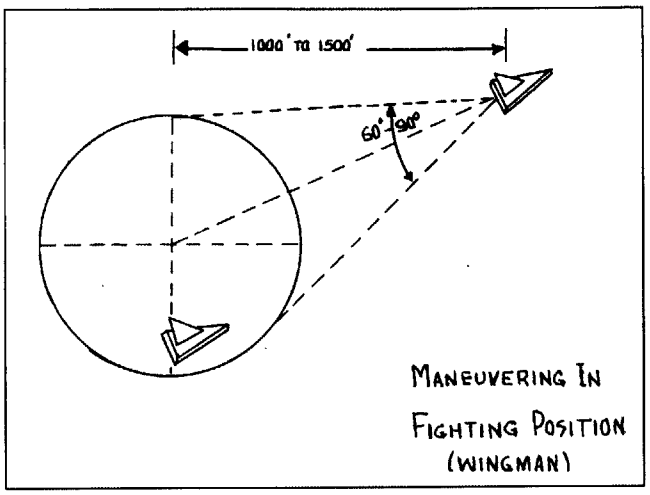

Figure 4.21. F-4C Fighting Wing Formation.
(Source: *8th TFW Tactical Doctrine*, Mar 1967, 73)

Welded wing possessed another significant disadvantage. In a Korean-era Sabre, the close position of the wingman allowed him to rapidly transition into an offensive position to fire his guns if so directed by his leader. In the missile-only F-4, this was not possible. With

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[213] Anderegg, *Sierra Hotel*, 21; Anderegg, interview, April 9, 2013; Anderegg, interview, October 2, 2013; Sokol, interview; Wallace, interview; Michel, *Clashes*, 170–72; Andrews, "To Fly and Fight," 162; Attinello, *Air-to-Air Encounters in Southeast Asia: Account of F-4 and F-8 Events Prior to 1 March 1967*, 187, 203–5. Wallace echoed Sokol's assessment, explaining that in fighting wing, "you were ... providing a shield between the lead and the guy [sneaking up from behind]." Anderegg noted that determining the proper spacing between aircraft was essentially a simple trigonometry problem: "It's obvious that if you're out fighting in an environment where [an enemy] missile has a range of 6,000 feet, then you need to be 6,000 feet apart to see 6,000 feet behind the other guy [based on the Phantom's ability to only see 45-degrees aft of line abreast]." Regarding the difficulty of flying as a wingman in the fighting wing position, one Phantom wingman noted following a successful engagement on April 29, 1966, that he became "completely disoriented during the various maneuvers and concentrated on staying on Lead's wing." During an engagement on May 8, 1966, two Phantoms actually collided, belly-to-belly; "both aircraft were damaged and place momentarily out of control, but they recovered."

the wingman closely following his flight lead, he and his GIB were unable to maneuver to obtain a "boresight" or "gyro out" radar lock. This meant that, in the off-chance a leader might request additional fire support from the wingman, the wingman was usually unable to provide it. Consequently, the formation arrangement effectively reduced the Phantoms' ordnance by half; a troubling statistic especially in light of the high failure rates of the American missiles. One pilot lamented of the practice, "You've got a whole damned weapons system back there that is kind of useless as far as employment is concerned."[214]

There were at least two other formation options. One was known as "double attack." It was initially developed by Air Force Captain Everest Riccioni based on his experiences flying F-100s in Europe in the late 1950s. In an unusually bold move for a new major temporarily assigned as an astronautics professor at the Air Force Academy, Riccioni in January 1963 sent a nearly forty-page memorandum direct to Major General Charles Westover, the vice-commander of TAC, extolling the benefits of his "double attack system." Riccioni acknowledged in the cover letter to Westover that his tone was a little brusque but explained that it was "necessary to shock fighter pilots out of 18 years of lethargic, uncreative thinking." Later that year, Riccioni published his ideas in the *Fighter Weapons Newsletter*. Essentially, his "double attack" formation involved a pair of aircraft flying line abreast, split by about one mile. Its distinguishing feature was that either the leader or the wingman could engage an enemy target based on whoever was most favorably aligned; there were no pre-assigned "shooter" or "looker" responsibilities. While some aircraft communities within ADC adopted elements of the "double attack" formation—for instance, the F-106 pilots used a version that they called "six-pac"— Riccioni's formation was widely shunned within TAC.[215]

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[214] Bedke, Oral History Interview, 41–42; Michel, *Clashes*, 171–72; Anderegg, interview, October 2, 2013; Sokol, interview.

[215] Riccioni to Westover, "Double Attack System"; Riccioni, "New Method of Employing the F-100C"; Riccioni, "Double Attack System"; Anderegg, *Sierra Hotel*, 59–60; Anderegg, interview, April 9, 2013; Anderegg, interview, October 2, 2013; Aerial Attack Section, 414 Fighter Weapons Squadron, "Anything Else Is Rubbish!"; Coram, *Boyd*, 237–38. Coram described Riccioni as a "curious fellow" who is "so sensitive that his feelings can be hurt with a harsh look, and he has an unending need for recognition." During his time teaching at the Air Force Academy, Riccioni authored *Tigers Airborne*, "a book on aerial tactics" that demonstrated both his "brilliance and naïveté." John Boyd, considered by some to be the Air Force's preeminent fighter tactician, disagreed with Riccioni's conclusions but refused to "pan the manuscript and his strong recommendation not to fire the author saved Riccioni's career."

The other possibility was the Navy's "loose deuce." It was similar to Riccioni's "double attack" in that in relied on a single, widely spaced element of two aircraft. When employed by its F-4B Phantoms, the Navy determined that the distance between the two aircraft "should ideally be between 6,000 – 9,000 [feet] and if possible 12,000 [feet]." Moreover, the Navy specifically recommended against flying its F-4Bs in a four-ship formation, preferring instead "two 'loose deuce' formations to retain a higher degree of tactical flexibility and for better mutual support between single units." Like in "double attack," the two-ship "loose deuce" was designed to take full advantage of each flight member's radar and missile load and it therefore avoided pre-designated "shooter" and "looker" responsibilities.[216]

Some Air Force Phantom aircrews in Vietnam began experimenting with the wider-spaced formations, especially the Navy's "loose deuce." One Phantom pilot, Ernest Bedke, remembered a period in mid-1966 when his unit started "spreading our formations and bringing people up to line abreast … where we had a better chance of looking for MIGs coming up at 6 o'clock." However, when a group of stateside Phantom instructor pilots happened to visit the unit and saw the combat pilots using a non-fighting wing formation, "they were aghast…. They threw the damned fighter manuals at us and told us that we had no idea what we were doing."[217]

The controversy over the proper positioning of the Phantom wingmen would continue for more than half a decade, reaching a fever pitch with a flurry of articles, both pro and con, in the 1971 issues of the *Fighter Weapons Newsletter*. Sokol, by then an F-4 instructor pilot at George AFB, California, remembered one of his fellow pilots working his Navy connections to score a copy of their "loose deuce" tactics manual. "We read about it. But we weren't allowed to teach it," Sokol recalled. In fact, "we had to hide that [manual],

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[216] Michel, *Clashes*, 169–72; Aust, "PACAF Tactics/Techniques Program (Bulletin #1)," 1:7–8; Riccioni, "Double Attack System," 27; Attinello, *Air-to-Air Encounters in Southeast Asia: Account of F-4 and F-8 Events Prior to 1 March 1967*, 47–49. The Navy's "loose deuce" was described in the attachment to PACAF's first Tactics and Techniques Bulletin. A pair of Navy F-4Bs was flying in "loose deuce" when they achieved the first Phantom victory of the Vietnam War on June 17, 1965. Riccioni noted in his article on double attack that "The Navy uses the term 'loose deuce' for their version" of his formation.

[217] Bedke, Oral History Interview, 41–421–2; Scott, *F-4C Fighter Screen and Escort*, 1–2. A July 1966 edition of the PACAF Tactics and Techniques Bulletin suggested using "loose deuce" if flying over water and under control of ground- (or sea-) based radar controllers. For all other situations, the bulletin declared "the normal formation is the 'fluid four.'" The difference could be attributed to the smaller chance of a surprise MiG attack when flying over the water, whereas when there was a greater chance of getting bounced by MiGs, the extra protection and visual lookout of the wingmen in "fluid four" was required.

because we were not allowed to have that book because it was heresy," and they threw the pirated manual "in the trunk of somebody's car" whenever the inspection teams showed up. "It was, by God, fighting wing.... You did not deviate from that," Sokol said of the period. Anderegg explained that it was "like ... pulling teeth" getting people to consider anything but fighting wing "because for ... thirty years, the Air Force [policy] had been [Number] One's the shooter and the wingman is the covering guy." Bedke, who had first encountered the resistance in Vietnam in mid-1966, similarly noted, "It takes a ball bat to the side of the head sometimes to convince [people] that they are antiquated and need to get up to speed and need to start looking ahead."[218]

It wasn't just the old-heads from Korea fighting to retain "fighting wing," though. For example, Richard "Steve" Ritchie, a young Captain flying Phantoms in Vietnam in 1972, was a big proponent of keeping his wingman in "tight fighting wing." Ritchie considered the emphasis on "strict, mutual support" an American "advantage over the enemy," despite the fact that one of his wingmen had actually lost control of his aircraft and had to eject while trying to maintain the welded wing position during a violent engagement. Ritchie had come to Vietnam from a tour instructing at the Air Force's Weapons School, and his attitude reflected that of his fellow instructors. In fact, some of the most vocal opposition to anything *but* fighting wing came from the halls of the Weapons School, widely recognized as the service's premier source of fighter tactics training.[219] Dismissing "loose deuce" as essentially "fluid four" without the wingmen, the Weapons School instructors wrote: "Fortunately that is not our cup of tea as number 2 and number 4 are very valuable to us.... We recognize that everyone is not as good as everyone else, and therefore place our people and plan the employment of our tactics accordingly." The instructors' argument smacked of hubris. It ignored the significant increase in offensive potential afforded by the wingman's missiles and the fact that since the Korean War, flying as a wingman had always been regarded as a significantly taxing responsibility, sometimes even more difficult than flying as

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[218] Roy, "Double Attack Revisted"; Aerial Attack Section, 414 Fighter Weapons Squadron, "Anything Else Is Rubbish!"; Skaret, "Double Attack Revisted One More Time"; Der Baron, 414 Fighter Weapons Squadron, "Anything Else Is Rubbish!," Fall 1971; Sokol, interview; Anderegg, interview, April 9, 2013; Anderegg, interview, October 2, 2013; Wallace, interview; Bedke, Oral History Interview, 42.

[219] The USAF's Fighter Weapons School located at Nellis AFB was considered the "graduate" school of tactical air warfare and its instructors some of the top fighter pilots in the Air Force. Hence, the instructors there carried exercised considerable influence in the development of fighter hardware and tactics. Wilson, "PhD for Fighter Pilots."

the flight leader. A far more reasonable concern with the new tactic, but one that was only seldom acknowledged, was the possible repercussions on the already too-crammed training timelines used to produce F-4 front seaters, and the schoolhouses' inability to devote the necessary time to teaching the new wingmen something other than fighting wing. But, as Michel noted, there was also little incentive to explore any potential options: "Since fluid four [and fighting wing] gave the flight leader a great deal of freedom because he knew he was always protected and could ignore his wingmen while pursuing the MiGs, it was not unpopular with the flight leaders," including those teaching at the Weapons School.[220]

The dogged resistance to any alternative formation also ignored some of the significant adjustments that had already taken place during the war. One was the Air Force's shift away from strictly coordinated four-ship tactics in favor of more flexible, two-ship element employment. Describing the shift, the 8th TFW's tactics manual explained that, based on the MiGs' patterns of attack, "It will be necessary for the elements to act as independent units until the threat is neutralized and a rejoin effected for mutual support." The new element tactics allowed one pair of Phantoms to engage the MiGs in a tight battle, keeping the enemy aircraft predictable and anchored in a general location, while the other Phantom element left the battle to gain sufficient separation—two to three miles—before they turned around in a better position to get a radar lock and use their missiles. The tactic was not simple. It required preplanning and good radio coordination between the leaders so that both did not try to separate at the same time, and so that when the separating element pitched back into the fight, the other element would know to vacate the area quickly to provide a clear avenue of fire for the distant element's missiles.[221]

Early combat experience also demonstrated that, between the variations in aircraft radar performance and the difficulty of obtaining a valid, long-range radar lock, it was unreasonable to assume that two Phantoms could reliably detect the same enemy aircraft

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[220] Ritchie, Oral History Interview, 12–14, 55; Anderegg, interview, October 2, 2013; Aerial Attack Section, 414 Fighter Weapons Squadron, "Anything Else Is Rubbish!," 34; Michel, *Clashes*, 171; Davies, *USAF F-4 Phantom II MiG Killers, 1972-73*, 8–9. Years later, Ritchie backtracked, claiming that he "would have preferred two airplanes—but the book said four [to a formation], and we couldn't get around that. So we used the elements as they were one airplane.... The wingmen were nothing but extra baggage most of the time." He also complained that he "spent 90 percent of my time over Hanoi trying to keep my wingmen from getting shot down." See Ritchie, Corona Ace Oral History Interview, 18, 28–29.

[221] *8th TFW Tactical Doctrine*, March 1967, 74, 97; *8th TFW Tactical Doctrine*, December 1967, 121, 150; Kirk, Oral History Interview, 16–17; Olds, "End of Tour Report," 7; Olds, Oral History Interview, July 12, 1967, 28–29, 37–38; Bakke, Oral History Interview.

with their radars. The aircrews couldn't even reliably communicate a target's elevation angle because of the known display errors in the Phantoms' cockpits. Hence, in instances when the wingman achieved a valid lock but the leader could not, the aircrews developed provisions that allowed the wingman to become a *de facto* leader as the formation neared the enemy. In these instances, the "scheduled" flight leader was supposed to maneuver into the fighting wing position behind his wingman. However, if the designated leader was finally able to obtain a radar lock, then the leader would assume the primary shooter responsibilities with the wingman supporting him.[222]

The Air Force's adoption of element tactics and flexible shooter arrangements resembled those central to the Navy's fluid "loose deuce" formation. In contrast, the Air Force's "pod" formation, which also became a staple of air combat in Vietnam, was extremely rigid. What was unique about "pod," though, was that it established a level of co-dependency between leader and wingman that had never been present in fighting wing. In "pod," each Phantom was to fly precisely 1,500 feet away and 1,500 feet above or below the next fighter; "modified pod" adjusted the vertical spacing to between 500 and 700 feet to make it easier to engage MiGs if required (figure 4.22). The formation spacing was designed to maximize the total coverage provided by each aircraft's ECM pod and help defend the entire formation against North Vietnamese SAMs. If any aircraft got out of position, a gap in the jamming pattern would develop and the individual aircraft or his neighbor would become a more inviting SAM

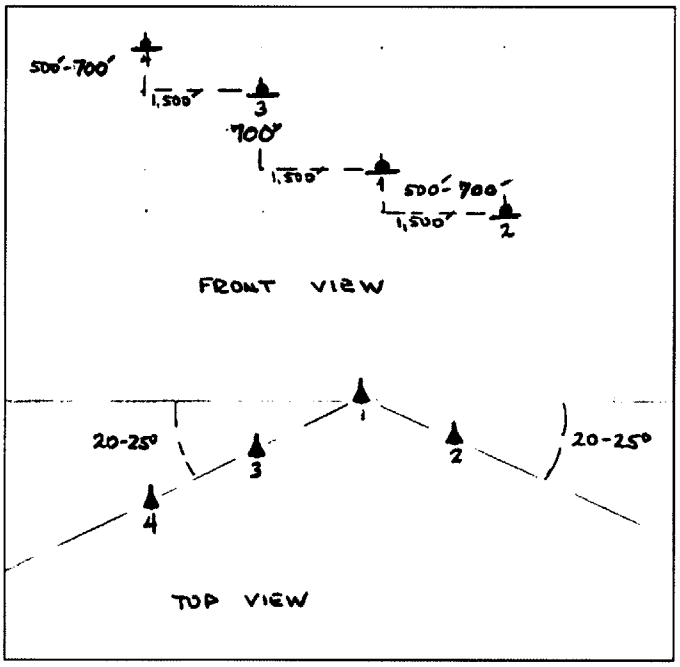

Figure 4.22. F-4C Modified Pod Formation.
(Source: *8th TFW Tactical Doctrine*, Dec 1967, 63)

[222] McCarthy, *Phantom Reflections*, 67; *8th TFW Tactical Doctrine*, March 1967, 96. See, for example, the description of the April 26, 1966, engagement in Attinello, *Air-to-Air Encounters in Southeast Asia: Account of F-4 and F-8 Events Prior to 1 March 1967*, 177–84.

target. While the wingman was still responsible for flying off of the flight leader, the flight leader had to make sure that his movements were more deliberate and easier to follow. Hence, "pod" represented a more-equitable partnership between flight lead and wingman.[223]

Still, despite these adjustments to the Phantom formations and tactics, fighting wing refused to die. Michel suggested that the Air Force's obstinacy may have stemmed from the fact that "loose deuce" was a "*Navy* formation …, and no Air Force officer with an interest in his career would dare suggest the Navy knew better than the Air Force." Although that might have been a contributing factor, TAC also proved reluctant to adopt the similar "double attack system" developed by the "curious" but Air Force-blue-wearing Riccioni. Perhaps more significant was the fact that, as Anderegg noted, "having a wingman as a shooter equals partner." But even this rationale obscures the fact that the wingman and his leader had already entered into a partnership to defend against SAMs using the "pod" formation.[224] Perhaps the transition to "pod" was made easier because the SAMs represented a tangible, technological threat, and the pilots' new formation was similarly designed to enhance a technological ECM-pod counter.

The same physicality of the artifacts—the SAM and the ECM pod—were not present in the case in fighter-versus-fighter air combat, and consequently, there was no obvious reasons to alter the preferred air-to-air tactics. To accept the wingman as functionally equivalent to the flight leader, even just for his offensive capability, in this environment would be "heresy." Moreover, to acknowledge the necessity of a new formation would violate the fighter pilots' arguments that, despite the arrival of radars and missiles, air combat had not changed. For example, the F-4 instructors at the Air Force's Weapons School at Nellis had recently invoked the pseudonym "Der Baron" and his oft-cited "… anything else is rubbish" saying in their editorial responses lambasting the "double attack" proponents published in the *Fighter Weapons Newsletter*.[225] The Phantom pilots'

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[223] *8th TFW Tactical Doctrine*, March 1967, 28–37; *8th TFW Tactical Doctrine*, December 1967, 58–63; Michel, *Clashes*, 60–63; Kimball, Oral History Interview, 3–4; Olds, "Briefing to the Staff of Project CORONA HARVEST on Operation BOLO," 20–21; Anderegg, *Sierra Hotel*, 21–22; Anderegg, interview, October 2, 2013.

[224] Michel, *Clashes*, 172; Anderegg, interview, October 2, 2013. Emphasis in original.

[225] Aerial Attack Section, 414 Fighter Weapons Squadron, "Anything Else Is Rubbish!". The instructors would continue to use the pseudonym and title for their editorial column for several years. See, for example: Der Baron, 414 Fighter Weapons Squadron, "Anything Else Is Rubbish!," Winter 1971; Der Baron, 414 Fighter

reluctance to adapt the formations and tactics that had proven successful for Richthofen and virtually every other pilot since can therefore be seen as reflective of their continued fascination with air combat in the context of the fighter pilot myth. It also preserved the fighter pilot legacy. The leader did the shooting. The wingman hung on, protected his leader, and watched and learned. This continued to be the "blooding" process by which a wingman proved his worth as a fighter pilot, and the pilots were unwilling to forsake it just because they and their adversary now carried missiles.

There was one other source of tension between the fighter cockpits that deserves mention—inter-flight communications and radio chatter. It was not a new issue. As noted in the previous discussion of the Korean War, the radio was often a source of considerable frustration for the Sabre pilots. With only a few channels available for communication among the scores of airplanes, and with the pilots often unable to restrain themselves from talking during the excitement of battle, the radio over MiG Alley was nearly always saturated. It could be maddening, but at least the MiG-15s had to get fairly close to score a kill, which increased the chances of the Sabre pilots detecting them before it was too late.

That was not necessarily the case with the Phantom in Vietnam. Several circumstances conspired to make the F-4's radio a more significant piece of equipment than in wars prior. For example, as noted earlier, the MiG-21's longer-range missile capability, coupled with the Phantom's restricted rearward visibility, rendered a timely "Break!" call from a flightmate one of the only ways a pilot would know to defend himself. There was also the requirement to pass radar target information between Phantom aircraft and between early warning aircraft like the EC-121. The Phantom aircrews' shift toward element tactics, including their initial sprint to obtain and communicate a VID, likewise depended on reliable radios. Finally, the radio intercom obviously played a critical role in intra-cockpit communications between the pilot and his GIB. Although perhaps guilt of hyperbole, Ritchie was thus not far off when he declared the UHF radio "the single, most important piece of equipment over North Vietnam. And then, the next most important thing were pilots and crews that knew how to use it."[226]

Weapons Squadron, "Anything Else Is Rubbish!," Fall 1972; Der Baron, 414 Fighter Weapons Squadron, "Anything Else Is Rubbish."

[226] Ritchie, Corona Ace Oral History Interview, 67–69; Ritchie, Oral History Interview, 8–9, 41–44. Unfortunately, the location of the radio did not facilitate rapid maintenance on the critical component because

Fortunately, the Phantom's radio system was also much more capable and versatile than the radio installed in the Sabre. The first F-4Cs used a UHF radio capable of receiving and transmitting on eighteen preset or one of 1,750 manually tunable frequencies. The radio set also incorporated a lower-power auxiliary receiver that could be tuned separately to receive (but not transmit) on one of twenty preset channels, plus an emergency "guard" frequency.[227] Considering that they were also listening to the radio intercom transmissions, the Phantom aircrews therefore had to become adept at listening to three different streams of information all being piped into their ears through the headsets in their helmets. Plus, there was also the requirement for the pilot to listen for the all-important and sometimes barely audible Sidewinder missile "growl" during the heat of a battle.[228]

The opportunity to select from a wide range of available frequencies was supposed to eliminate crowding on a limited number of radio channels as was experienced in Korea. However, radio saturation remained a problem. The issue wasn't the availability of the radio spectrum, but the availability of the information transmitted over that radio spectrum. For example, all the aircrews wanted to be able to listen to the MiG warnings provided by the early warning aircraft, but according to one EC-121 aircraft commander, "once everyone got on the same frequency the load was just too much.... There were delays and sometimes messages [were] not received." Sometimes, the F-4 escort fighters would use one frequency while their accompanying F-105 fighter-bombers used another, under the understanding that if the two aircraft types needed to communicate with one another, they could simply change their radio channel. But one Phantom pilot noted, "you hated to [switch frequencies and] miss one fraction of a second of something that may be coming over [the radio]." Another pilot remembered that it wasn't uncommon to finish his aerial refueling and then push North into Vietnam listening to "fighters who were trying to coordinate their activities within flights and between flights, ... reconnaissance aircraft up there that were calling off

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the repair crews needed to first extract the GIB's ejection seat from the cockpit before they could reach the radio set.

[227] *T.O. 1F-4C-1*, 1–40–48. Later radios included an option for the pilot to reprogram the preset radio frequencies in the jet. They also offered a wider range of manually tunable frequencies.

[228] Kimball, Oral History Interview, 13; Olds, Oral History Interview, n.d., 72–74; Sokol, interview.

various things, and the air-sea rescue people [who] were operating on the same frequency.... In some cases [you] have to have all those people on the same frequency."[229]

Commanders continued to emphasize the importance of radio discipline, keeping "the communications ... as simple as you possibly can" and "keep[ing] the chatter down." However, when the pilots' blood pressures rose during a fierce battle, their voices tended to follow, and any inter-aircraft "brevity" code or intra-aircraft "descriptive commentary" that was designed to facilitate radio discipline was quickly discarded. One Phantom pilot remembered, "every now and then you'd have some motor mouth ... and then somebody would soon yell 'shut up' ... but that wouldn't always necessarily shut him up." Avoiding the possibility of having a "motor mouth" in the back seat, garbaging up the intercom and radio, was one of the arguments the front seaters invoked for keeping a trained pilot in the back seat of the Phantom instead of using a navigator-GIB.[230]

Even without a "motor mouth" monopolizing the radio time, making sense of the cacophony of radio transmissions could be a challenge for the aircrew, and it added to the complexity of employing the Phantom in combat. Consider, for example, the radio transmissions that a single Phantom—Cadillac 1—had to process during a two-minute span from 13:17:00 to 13:19:00 on July 29, 1972. During the brief 120-second span, there were a total of thirty-three radio transmissions of varying volume, intensity, and duration. They included: the intercom communications between the pilot and the GIB as they struggled to locate and target a nearby MiG; their wingman, Cadillac 4, transmitting that he "just took a hit"; another aircraft transmitting on the emergency "guard" frequency as he tried to locate his flightmates; numerous directions from the radar controllers at Red Crown trying to help Cadillac 1 find the elusive MiG; inter-flight transmissions from two other nearby flights, Pistol and Trigger, who were also trying to chase down the MiG; and transmissions from another group of F-4s getting ready to drop their bombs. As one pilot noted of the general situation, it could be "difficult to tell who said what, on what frequency it came in, where to

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[229] Morris, Oral History Interview, 16; Kimball, Oral History Interview, 11; Bedke, Oral History Interview, 26–27; Olds, Oral History Interview, n.d., 33, 60–61.

[230] Bedke, Oral History Interview, 28; Kimball, Oral History Interview, 12; Ritchie, Oral History Interview, 26; Hendrickson, Oral History Interview, 12; Attinello, *Air-to-Air Encounters in Southeast Asia: Account of F-4 and F-8 Events Prior to 1 March 1967*, 161, 309, 324.

respond to it, or if you should even respond to it."[231] The significance attached to the radio communications is illustrated by the fact that the aircrews began carrying personal, portable cassette recorders to capture the voice information for mission documentation.[232]

The pilots' experience with their radios was unique in that, unlike the radar or the missiles, operating the system did not pose a major technical challenge to the aircrews. Rather, the difficulty resided primarily in the cognitive or information-processing realm. For example, Ritchie noted that with "so much information coming in over the radio, the weather, the field, the instruments, the back seater, all this coming in over the headset … it has almost got to be a computer-type thinking process where you sort it out."[233] Thus, the increasing significance of the radio communications provides one more marker in the evolving character of air combat and the corresponding shifts in the fighter pilots' necessary skill set.

The aircrews in the Phantom were therefore confronted with several unique challenges unknown to the earlier aviators. As Olds alluded to in his comments on flying the Mustang versus the Phantom, things were different. While some of the challenges stemmed from the complexity of the F-4's equipment, many of the challenges for the aircrews spilled over into less procedural or technical realms. Tensions within the cockpit associated with forcing a winged pilot to ride in the back seat, or having a pilot fly in the front seat while listening to someone in the back seat, as well as the pilots' general reluctance to adjust their time-honored and culturally significant formations and tactics are but a few examples of the challenges that accompanied the Phantom and its crews into battle. Many were never resolved, but the aircrews nonetheless still blasted off every day hunting for MiG glory. But an important question remained unanswered. With two pilots aboard, who would get the credit for downing a MiG?

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[231] Harmer and Anderegg, *Shootdown of Trigger 4*, 30–39; Kimball, Oral History Interview, 13. The transcript of the Cadillac 1's mission on July 29, 1972, is included in Harmer's and Anderegg's report. The engagement was noteworthy because there was concern that Cadillac 1 might have shot down a friendly Phantom. Harmer and Anderegg concluded that the aircrew did not and instead shot a MiG. A more accessible mission transcript of Ritchie's fifth kill can be found in Futrell et al., *Aces and Aerial Victories*, 20–22. Unfortunately, Futrell's transcription only included the transmissions relevant to the victory and excluded the numerous other extraneous transmissions that vied for the aircrew's attention.

[232] Harmer and Anderegg, *Shootdown of Trigger 4*, 3, 5; Sokol, interview.

[233] Ritchie, Corona Ace Oral History Interview, 31.

Who Gets the Credit?

On October 15, 1972, Captain Gary Rubus was trying desperately to down a MiG-21. Rubus eventually maneuvered his F-4E to within 1,100 feet of the enemy aircraft and squeezed the Phantom's trigger. His aim was true and the Phantom's 20-mm rounds began ripping through the center of the MiG's fuselage. Rubus continued to close on the enemy and fired again from 800 feet away. Moments later, the MiG's canopy shot off and the enemy pilot ejected. After the mission, Rubus's navigator-GIB, Captain James Hendrickson, was asked if he should have also received credit for his front seater's gun-kill. Hendrickson replied, "In this particular case, I think it's deserved if you really want to be honest about it." It was an interesting appraisal. Hendrickson had no direct involvement with Rubus's gun attack, other than reminding his pilot to "arm up your nose gun" and, when they were about 1,500 feet back, shouting over the intercom, "You're in range. Fire." In fact, the three prior Sparrow missile attacks that Hendrickson had direct involvement with had all ended in failure; hence Rubus's decision to forego any additional missile attacks in favor of the more reliable gun.[234]

Hendrickson's argument was based on the fact that without his help, his aircraft commander would have never found the enemy MiG, a fact that was obscured in Rubus's post-mission report that simply stated, "A radar contact was established at a distance of 16 nautical miles, followed by a visual contact shortly thereafter." Hendrickson noted that the MiGs were flying below the clouds and out of sight. It was Hendrickson's skill and dexterity manipulating the radar that had allowed him to detect the MiGs, and then he still needed to coax his pilot down and into position. "They're low. Continue on down," Hendrickson reportedly told Rubus. When the MiGs suddenly started to drift off the radar scope, Hendrickson had to provide further guidance to his pilot, "They're starting to drift to the right, hard right, hard right." Only then did the MiGs finally appear through the clouds, permitting Rubus to take over visually.[235]

Prior to the Phantom, Air Force fighter pilots had never before had to share their aerial glory with another. Even their wingmen in Korea and Vietnam had been effectively shut out based on the preferred "lead-shooter" formations and tactics. If victory credit was

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[234] Hendrickson, Oral History Interview, 47, 57; Futrell et al., *Aces and Aerial Victories*, 110.

[235] Hendrickson, Oral History Interview, 45–47; Futrell et al., *Aces and Aerial Victories*, 110.

now to be awarded to a GIB who could not physically pull the trigger, where exactly would the claims for credit and glory end? But, the Phantom had been engineered specifically to capitalize on the collective contributions of the pilot and the GIB, as well as host of other semi-automated and automated hardware components. It was going to be exceedingly difficult to now attempt to disaggregate those contributions so that credit for downing a MiG could be properly awarded to a single individual. The ruthless simplicity and apparent objectivity that had made the aerial victory credit so appealing and a fixture in the fighter pilot myth seemed to now be under attack by the complexity of modern air combat.

Documenting the Phantom's Air-to-Air Performance

The Phantom's recording mechanisms certainly did not facilitate assignment of victory credit between the crew members. Like the earlier Sabre, the F-4C Phantom included a camera to document the aircraft's performance. However, whereas the Sabre's camera was mounted in the aircraft's intake so as to record spectacular images of enemy aircraft erupting in flame under the steady stream of well-placed bullets, the Phantom's camera was mounted in the rear cockpit and took pictures of the GIB's radar scope. That was where the action in the Phantom was supposed to take place, and it was an apt reflection of the significance that the engineers attached to the GIB and his role in fulfilling the promise of the Phantom's long-range air combat capabilities. Moreover, a forward facing gun camera would be of little value trying to record images of missiles impacting an enemy aircraft miles away and not necessarily directly in front of the Phantom.

McDonnell's Direct Radar Scope Camera was touted as a major innovation and a specific "advantage" of the Phantom when it was unveiled. One of the advertisements for the Phantom noted that the "low cost, low volume, reliability, simplicity, inflight reloading, recording capabilities and projector playback characteristics of this device made it ideal for crew training and evaluation." The Navy was so impressed with the system that they asked for it to come standard in their production models of the F-4B, and the Air Force followed suit. The radar camera used a fifty-foot reel of 16-mm film. Once the GIB turned it on, the radar camera snapped a picture of the scope at the end of each antenna azimuth sweep. If the radar entered track mode, the camera took pictures at an accelerated rate of between two and six frames per second (GIB-selectable). Sokol and Anderegg, however, both remembered the system as being less than perfect. Anderegg recalled that frequently the

door "would come open and it wouldn't run. And you had to wait four or five days for the developing process. It was just a big pain in the ass." Sokol wondered, "Who wants to watch a film of the [radar]? It was bad enough doing it, let alone watching it."[236]

When then Phantom began participating in the close-range battles over Vietnam, the rear-cockpit radar camera proved wholly inadequate. The radar camera had no capability to record the pilot's employment of the Sidewinder or, after they were added to the Phantom's air-to-air arsenal in May 1967, the external gun pods. Even with a Sparrow, the radar camera could at best only record the disappearance of a "fuzzy blip" following a missile launch—not at all a guarantee of a successful engagement. Olds complained during his briefing following Operation Bolo that the lack of a viable camera had cost his Phantoms a potential eighth MiG claim.[237] The situation was partly corrected in late 1971 when the Air Force began evaluating a new gunsight camera designed to record images through the F-4D/E's optical sight. The new "gunsight camera system," the Phantom pilots noted, would finally "satisfy a long-standing requirement" and allow for proper "film documentation of the techniques employed in ... air-to-air training situations."[238] However, it would take several months before the new cameras began appearing on the Air Force's Phantoms, and they never arrived in sufficient numbers before the end of the war.

Hence, the Phantom would produce no inspiring gun camera imagery to memorialize its role as the Air Force's workhorse fighter of the Vietnam War. Instead, ironically, the iconic air-to-air image of the Vietnam War was captured by an F-105 Thunderchief fighter-bomber in mid-1967 (figure 4.23). More significantly, the Phantom pilots lacked the gun camera imagery that was normally needed to validate a pilot's claims of aerial victory. The Phantom crews therefore often relied on their flightmates' written testimonies to validate their claims, all of which had to be compiled and forwarded to Wing headquarters within twenty-four hours of the shootdown. The Wing claims board would then review the information and, if validated, send the pilot's claim and supporting documentation to the

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[236] "Advantage Is Here: How the Phantom Records What the Radar Sees"; *T.O. 1F-4C-34-1-1*, 1–70–72; Anderegg, *Sierra Hotel*, 103; Anderegg, interview, October 2, 2013; Sokol, interview.

[237] Olds, "Briefing to the Staff of Project CORONA HARVEST on Operation BOLO," 62. Olds also complained that the Phantom had no adequate capability to record its bombing attacks. See Olds, "End of Tour Report," 31–32.

[238] Sexton and Jameson, "New F-4 Gunsight Camera"; Anderegg, *Sierra Hotel*, 103–4.

officials at Seventh Air Force who would then revalidate the claim before awarding final credit.[239]

The combination of no photographic evidence and all-too-eager wingmen ready to validate a leader's claim might suggest that over-claiming aerial victories in Vietnam would be as rampant as in past wars. However, the issue seemed to rarely surface. One reason was the US's greater intelligence gathering capabilities, which was often used to validate the Phantom pilots' claims. For example, it was the US's ELINT (electronic intelligence) capability that Olds blamed for not allowing his unit to claim an eighth MiG during Operation Bolo. The same national intelligence apparatus also kept close watch over the Phantom aircrews' conduct of the war. Thus, unlike with the Sabres in Korea, there was very little separate hunting or individual attempts to take advantage of otherwise off-limit MiGs operating near their home airfields. The greater oversight of the Phantom pilots meant that the Wild West atmosphere that previously characterized the battles north of MiG Alley in Korea had largely disappeared by Vietnam.[240]

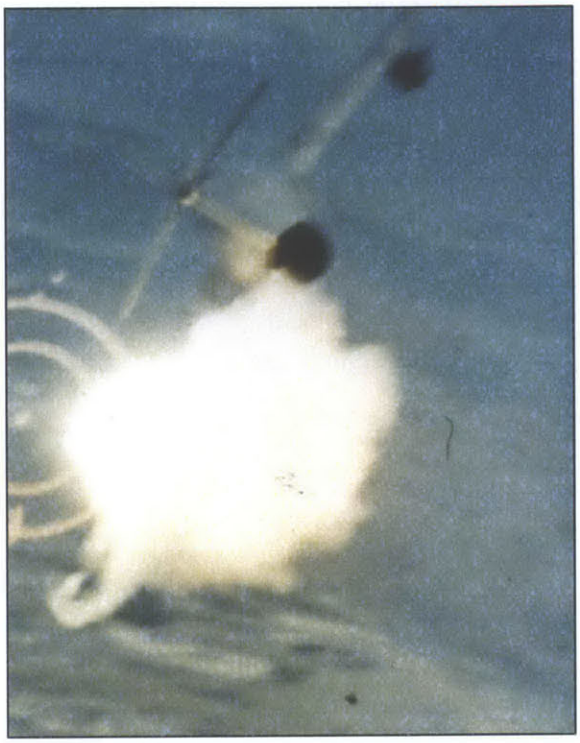

Figure 4.23. An F-105D Flames a MiG-17.
Ironically, this iconic image of fighter combat over Vietnam was not captured by the Air Force's air-to-air workhorse; although the Phantom had begun scoring close-range kills with its external gun pods by June 1967, it had no camera to record the victories.
(Source: NMUSAF)

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[239] Futrell et al., *Aces and Aerial Victories*, v.

[240] Olds, "Briefing to the Staff of Project CORONA HARVEST on Operation BOLO," 63. Unlike in Korea, the Air Force had no tolerance for border violations. A wayward EB-66 aircraft, escorted by pairs of Phantoms, had twice violated Chinese airspace in mid-1966. On one of the occasions, the Phantoms had shot down a Chinese MiG that had come to intercept them. The Air Force, under heavy pressure from "high Washington levels," implemented a number of measures to minimize the chances of future border excursions. See Van Staaveren, *Gradual Failure*, 274–77. One of the more notorious breakdowns in aircrew discipline occurred when a flight of F-105s "accidentally" strafed a Russian ship in Haiphong harbor. The situation was exacerbated when the aircrews' base leadership tried to conceal the incident by destroying the Thud pilots' gun camera film. When an investigation by General John Ryan uncovered the malfeasance, the base's acting wing commander, Colonel Jack Broughton, was summarily sacked and court-martialed. For more details, see: Ryan, Oral History Interview, 114–17; Olds, Corona Ace Oral History Interview, 86–90; Olds, *Fighter Pilot*, 320–22; Correll, "Man from Thud Ridge."

The desire to claim a MiG that had once driven Sabre pilots north of the Yalu River had not dissipated, though. If anything, the relative scarcity of enemy MiGs over Vietnam, and the fits and starts with which they appeared, stoked the Phantom pilots' enthusiasm to be one of the few who scored a victory. Sokol never encountered a MiG during his tours, but to have gotten one, he admitted, would have been like "winning the lottery." Hoyt Vandenberg Jr., son of the first CSAF, noted of his time flying Phantoms in the 366th TFW at DaNang, "Everybody wanted to be a MiG ace. Right? That was the pinnacle in Vietnam, so in order to find MiGs, you had to get up there and mix it up."[241]

Pushing for the Next Air Force Ace

It wasn't just the Phantom pilots that were enamored with the allure of aerial victory. After having heavily marketed the ace-figure during the Korean War, the Air Force as an institution also eagerly anticipated its next round of aces to emerge from Vietnam. When the individual aces failed to materialize, the Air Force decided to start applying the "ace" moniker to its squadrons and wings that had accumulated a total of five aerial victories.[242]

Olds came the closest to downing the magic number of five enemy aircraft. After having scored his first MiG with Clifton during Operation Bolo on January 2, 1967, it took Olds another four months before he downed another MiG on May 4, 1967. Two more MiGs followed less than three weeks later on the twentieth. Olds, however, never got his fifth. Years later, he would claim that he was tipped off that if "I got number five, I would be sent home" for "PR [Public Relations] purposes." Unwilling to forego his prized Wing commander job, Olds said that he spent the next four months "knowing that if I squeezed my trigger finger, I would lose my job," and he ended up letting his wingman "get the MiGs. That was a little hard to take," he admitted. While it's difficult to verify Olds's claim, the fact remains that he completed his tour with only four victories, and no other Air Force pilot had matched it by the end of Rolling Thunder.[243]

The Air Force might have been able to overlook its lack of an ace except that when air combat resumed in 1972, the Navy produced its own set of aces. On May 10, 1972,

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[241] Sokol, interview; Vandenberg, Oral History Interview, 145.

[242] See, for example: "Air Force Phantom Crews Get Two More"; "'Ace' Fighter Wing Commanded by 'Aces.'"

[243] Olds, Corona Ace Oral History Interview, 45–47; Olds, *Fighter Pilot*, 318–20; Futrell et al., *Aces and Aerial Victories*, 52, 59–60, 134.

Lieutenant Randy "Duke" Cunningham and his RIO, Lieutenant (JG) Bill "Irish" Driscoll, downed three MiGs in a single day. When added to their previous pair of victories, the two crewmembers became the first American aces since Korea. As the Air Force had purportedly hoped to do with Olds, Cunningham and Driscoll were spirited out of combat and back to the States to "transmit first hand and freshly to their colleagues their experiences of aerial combat." But along the way, one Navy official acknowledged, the two aviators were entitled to "a little exposure and a little reward."[244]

The Air Force, if it was to retain its image as the nation's premier air service, desperately needed its own ace. The same day that Cunningham and Driscoll scored their fifth MiG, Ritchie and his WSO, Captain Charles DeBellevue, maneuvered behind a MiG and launched two Sparrows at it. The first missile failed to detonate, but the second missile sent the MiG flaming toward the ground. It was the first victory for both crew members. Over the next four months, Ritchie would use his Sparrow missiles to amass three more kills against the North Vietnamese MiG-21s, two with DeBellevue again in his back seat. Ritchie's final and all-important fifth kill came on August 28, 1972, when he and DeBellevue detected a MiG-21 fifteen-miles ahead and 10,000 feet above them. Ritchie lit the afterburners and executed a hard, climbing left turn to arrive at the MiG's six o'clock, about four-miles back, just slightly out of the Sparrow's maximum range. During the initial maneuver, Ritchie had fired a pair of Sparrows that he knew were "out of parameters" but that he hoped might "get the MiG to start a turn." The MiG failed to take the bait. After he had rolled out behind the MiG, the massive engines in the Phantom began to power Ritchie closer to the MiG and into a better firing position. Ritchie let loose with his last two Sparrows. "The third missile missed, but the fourth impacted the MiG," which was "seen to explode and start tumbling toward the earth."[245]

Unlike America's first ace in Korea, Ritchie looked more like the prototypical ace. He was once described by Olds as "brilliant. He is good looking. He is dedicated. He is everything that we wanted." Ritchie was born and raised in Reidsville, North Carolina, home to one of American Tobacco Company's major manufacturing plants, where his father

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[244] Michel, *Clashes*, 214; Blumenthal, "First 2 Aces of Vietnam War."

[245] Ritchie, Oral History Interview, 45–47, 50–58, 60–62; Ritchie, Corona Ace Oral History Interview, 91–97; Deen, "How Steve Ritchie Got His Fifth MIG"; Futrell et al., *Aces and Aerial Victories*, 20–22, 93–99, 102–3, 116. DeBellevue was away on leave when Ritchie scored his second kill.

worked as an executive. Ritchie was selected to attend the Air Force Academy, and while there, he "walked-on" to the varsity football team and played as the team's starting halfback in the 1963 Gator Bowl. He graduated from the Academy the same year as Clifton in 1964, and a year later, finished first in his pilot training class at Laredo AFB, Texas. Deciding midway through pilot training that he "never wanted to fly anything with more than one seat," Ritchie opted for one of the four F-104 Starfighters available to his class. Only later did he realize that the F-104 was a "non-combat assignment," and he spent the next two years at Eglin AFB flying "safety chase on test missions on the range." Looking to transition into TAC and into an F-105, he was instead picked for an F-4D front seat assignment to DaNang, where he arrived for his one-year tour in 1968. From there, Ritchie was assigned to Nellis AFB where he completed the Air Force's Weapons School program in the Phantom before volunteering to stay on and serve as an instructor. After his assignment at Nellis, he volunteered for his second tour in Vietnam and arrived in January 1972, just a few months prior to the resumption of the air war over North Vietnam.[246]

Olds and others would later imply that Ritchie had been handpicked to become the Air Force's first ace, much like Jabara had been in Korea. Ritchie denounced the rumors, explaining that with the unpredictability of the North Vietnamese MiGs, "there's no way they could give you the right missions." But he did enjoy certain technological benefits that had been unavailable to other pilots, including the Combat Tree system on the F-4D, which allowed him to interrogate the MiGs' radar transponders and detect their positions. Ritchie's AIM-7E-2 Sparrow missiles also achieved an uncharacteristically high success rate of nearly 55 percent; a product of more delicate handling and routine diagnostic testing of his missiles that Ritchie insisted take place after every ten flights. Ritchie also took great care to establish personal contact with his maintenance troops and the radar controllers that might vector him toward a MiG one day. On the day that he shot down two MiGs, his radar controller reportedly broke protocol and simply transmitted, "Steve, they're two miles north of you." Importantly, Ritchie also had the benefit of flying with a regular WSO, DeBellevue. As Ritchie explained, he and DeBellevue "had flown enough that Chuck knew exactly the information that I needed.... I don't have to say from the front, 'Chuck, is it a good lock?'

[246] Ritchie, Corona Ace Oral History Interview, 1–11; Olds, Corona Ace Oral History Interview, 118–19; Sherwood, *Fast Movers*, 216–19. Olds noted that Ritchie's only flaw was that "he thinks he is god's gift to [fighter aviation].... Steve has a monstrous ego."

And he says, 'Yes, it's a good lock.' He knows to tell me at that instant that it's a good lock."[247]

When Ritchie and DeBellevue landed from their eventful sortie, their squadron-mates from the 555th "Triple Nickel" TFS gathered round their aircraft shouting congratulations. The aircraft's assistant crew chief, Staff Sergeant Frank Falcone, held a stencil of a large star against the aircraft and handed a can of red spray paint to the victorious pilot. As was the practice, Ritchie filled in half of the star and then handed the can over to his GIB to finish it off. Within hours, a message from the Secretary of Defense, Melvin Laird, arrived for Ritchie: "My warmest congratulations are extended to you as the first US Air Force 'ace' of the Vietnam conflict. You have earned a special salute."[248]

Fittingly, that year Ritchie was awarded the Colonel James Jabara Award for Airmanship, which recognized the Air Force Academy graduate "whose airmanship contributions are of great significance and set them apart from their contemporaries." Ritchie was also a recipient of the National Aeronautic Association's Mackay Trophy, awarded for the "most meritorious flight of the year." There were two other recipients of the Mackay trophy that year—the Air Force's other two aces that followed Ritchie. DeBellevue was one. Captain Jeffery Feinstein was the other. Both were WSOs. Ritchie was the only Air Force ace from the Vietnam War that had ever squeezed the trigger.[249]

Lingering Tensions

In Spring 1972, General John D. Ryan, the CSAF, decreed that both pilot and GIB would receive full credit for each enemy aircraft destroyed in combat. Prior to that, the standard policy was to divide the aerial victory credit between the pilot and GIB if both contributed to the kill, similar to what was done if two pilots had both claimed the same victory during Korea or World War II. Therefore, although Olds had shot down four MiGs, Futrell et al. noted that he had only received official credit for two downed aircraft when his combat tour was up in October 1967.

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[247] Olds, Corona Ace Oral History Interview, 44; Olds, *Fighter Pilot*, 379; Ritchie, Oral History Interview, 4, 31–32; Ritchie, Corona Ace Oral History Interview, 15–16, 35, 38, 62; Sherwood, *Fast Movers*, 244–45; Futrell et al., *Aces and Aerial Victories*, 103.

[248] Deen, "How Steve Ritchie Got His Fifth MIG."

[249] "US Air Force Academy Jabara Award"; "National Aeronautic Association Mackay Trophy"; Futrell et al., *Aces and Aerial Victories*, 103–5, 109.

Unfortunately, I have been unable to locate the official rationale for the shift in Air Force policy. Anderegg suggested that the change stemmed from when General Ryan's son, 1st Lieutenant John D. Jr. was flying as a GIB. Apparently, when John Jr.'s front seater used an AIM-4D Falcon to down a MiG on December 17, 1967, General Ryan, then serving as the commander of PACAF, called to congratulate his son on becoming a "MiG killer." However, John Jr. reminded his father of the policy and explained that he wouldn't receive full credit for the kill. It is also possible that the policy change was made simply to mirror that used in the Navy, or to help improve the Air Force's odds of finally anointing an ace. Whatever the reason for instituting it, General Ryan's new policy was made retroactive to April 1965, which corresponded to when the Air Force's first Phantoms arrived in SEA.[250]

Hence, there was never any real debate over whether Hendrickson would receive credit for his front-seater Rupus's gun kill in October 1972, nor was there any question when the two GIBs, DeBellevue and Feinstein, achieved ace-status. In fact, DeBellevue would score a total of six kills during the war, placing him at the top of the roll of Vietnam aces. But, while Ryan's policy obviously appealed to the GIBs, it was generally not well-received by those who occupied the Phantom's front seat. Welch recalled "grousing" among the pilots and sarcastic arguments that if the Air Force was going to extend credit to the GIB, "why don't you give the wingman credit [too]? The wingman is just as responsible for your being in position to kill an enemy airplane as the guy in the back seat.... And, by the way, how about the crew chief [that maintains the plane]?" Everest, the commander of the first F-4C training unit at MacDill, also disagreed with the policy, but noted that the GIB "helped in most cases." Burns was more damning; he declared the policy "not good.... I think it confused the hell out of things."[251]

Few in the public sphere even took notice. The five Vietnam aces—two Navy and three Air Force—never received the public accolades or the headlines that were afforded to their earlier counterparts. Perhaps the ambivalence was related to the unpopularity of the tiresome Vietnam War, or the fact that the aviator-ace had been supplanted by the next generation of national heroes wearing silver-metallic spacesuits. What is clear is that the Vietnam aces were never trotted out in front of crowd of twenty thousand at Fenway like

[250] Futrell et al., *Aces and Aerial Victories*, vi, 136; Anderegg, interview, October 2, 2013.

[251] Welch, Oral History Interview, 90; Everest, Oral History Interview, 14; Burns, Oral History Interview, June 5, 1984, 219.

Jabara. In fact the *New York Times* made no mention of Cunningham and Driscoll becoming the first American aces since Korea until they arrived in New York two weeks after the mission for a swank dinner at the restaurant 21 in Manhattan, "courtesy Grumman"—the manufacturer of the Navy's next fighter, the F-14 Tomcat. Ritchie's accomplishment was recognized in a more timely manner, appearing in print on August 30, but it was buried on page sixteen and it lacked the customary thrilling account of the aerial duel that was a feature of earlier reporting on the aces of Korea. If an individual wasn't already familiar with the cockpit of the two-seat Phantom, they might miss the note that accompanied the announcement of DeBellevue's achieving ace status as a "backseat weapons systems operator." Feinstein's achievement, which occurred the same day that Rubus and Hendrickson got their gun kill, was buried in a column on the air war in general and made no mention of his position in the cockpit.[252]

One group that did take notice of the anomaly, however, was the American Fighter Aces Association. A private organization established in 1960 to "preserve and promote the distinguished heritage of the American combat fighter ace," and to recognize the "special distinction of becoming an ace by destroying five or more hostile aircraft in air to air combat," the Fighter Aces Association maintains a roll of all American fighter pilot aces since World War I. For the Vietnam War, the association only recognizes two aces: Randy "Duke" Cunningham and "Steve" Ritchie.[253] The conspicuous absence of the ace-GIBs—Driscoll, DeBellevue, and Feinstein—is a reminder of the still-lingering tension over the role of the GIB in fighter combat, and the fighter pilots' attempts to preserve their place in the cherished myth of the self-sufficient fighter pilot. Despite their vital role in victory, the GIBs remain still little more than "castrated tomcats" in the eyes of many of the nation's ace aviators.

Conclusion

In March 1915, Roland Garros decided that he'd prefer risking shooting off his own propeller rather than continue to chauffeur around an observer-gunner who persistently failed to see, much less hit, an enemy aircraft. Almost exactly fifty-years later, the observer-

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[252] Blumenthal, "First 2 Aces of Vietnam War"; "First Air Force Ace in Indochina"; "Air Force Captain Gets 5th MIG"; "Saigon Reports Sharp Fighting."

[253] "American Fighter Aces."

gunner was back in fighter combat. Except now, instead of looking through oil-smeared goggles and swinging his machine gun around to fire on an approaching enemy, the observer stared at a cathode ray tube in the back of the Phantom II and let his rocket-powered, guided Sparrow missile do the turning for him. The interpersonal tension that Garros had conveniently avoided when he abandoned his human baggage at the aerodrome had suddenly resurfaced. In the new Phantom, these lingering interpersonal issues became enmeshed in sometimes cumbersome human-machine dynamics, and both exerted a considerable influence over the combat performance of the Air Force's newest fighter aircraft as it entered combat over Vietnam.

When the first F-4Cs began showing up on TAC flightlines in 1963, the pilots were ecstatic. Although the Phantom may have originally been designed for the Navy, it reflected the Air Force's aspirations of the post-Korean era. The Phantom was the fastest aircraft in the world at the time. It could zoom to near-stratospheric altitudes. And, when combined with its long-range weapons system, it would ensure that no American Air Force fighter pilot would ever have to endure the humiliation of watching enemy MiGs trace lazy contrails in the sky high above them again. While other Air Force aircraft had been pursuing advanced radars, fire control systems, and guided missiles for years, the arrival of the Phantom heralded TAC's first significant foray into the new age of aerial combat. Hence, the initial cadre of TAC pilots hand-picked for the Phantom was understandably excited to take wing in what was widely regarded as the most powerful aircraft in the world.

They soon learned that some aspects of flying the new fighter were no different than before: pulling back on the stick still made the nose pitch up, and the aircraft still rolled to the left when the pilot pushed the stick in that direction. Other changes simply represented a difference in kind. For example, the pilot now had two throttles instead of one. But, there were also more dramatic changes. The large radar scope mounted prominently in front of the pilot was a noticeable deviation from the standard fighter cockpit designs of the past. And then there was the GIB.

In the earlier Sabres, fighter pilots had complained of too much automaticity in the APG-30 that did not allow them proper control over the radar (assuming it was even working). With the F-86D's E-4 fire control system, there was less automation and the interceptor pilots enjoyed significant control over the radar and its targeting, but "flying instruments" off a television screen mounted between the pilots' knees proved unpopular as

well. The engineers working on the Phantom wanted to provide the desired flexibility in the radar's operation, but their studies had shown that a single pilot would not have the attention to devote to operating the complex radar. The GIB in the Phantom was to be the answer. The two crewmembers would work together as a team, seamlessly passing critical target information between cockpits using the Phantom's radio intercom.

However, the well-engineered design encountered difficulties in practice. Most pilots weren't especially keen about opening their cockpit space to another individual. And, under the Air Force's policy of assigning newly winged pilots to the Phantom's back seat, most GIBs weren't too enthused about riding in the Phantom either. Most from both seats would have preferred to instead be flying a single-seat fighter, even if it was an older, less sophisticated, and more vulnerable aircraft. The consequent tension that erupted within the cockpit threatened to undo the years of intricate planning that had guided the engineers' decisions about how best to divvy up the tasks among the aircraft, the missiles, and the humans. An aircraft commander that told his junior GIB to "shut up" and "go cold mike" violated one of the engineers' basic design assumptions. A GIB that failed to learn the intricate procedures and flexibility of the radar because he was too focused on eventually transitioning to the Phantom's front seat similarly contravened the intended division of tasks.

Nor did the reality of air combat over Vietnam conform to the intended design. Uneven terrain, VID requirements, and small, nimble MiGs frequently rendered the Phantom's radar and missiles ineffective. Both crewmembers were therefore confronted with additional technical challenges localized within their specific sections of the cockpit. Some problems were resolved simply with a piece of plastic tubing placed over a troublesome switch. Others required more ingenious tinkering, such as developing new boresight lock procedures or a method to use an external gun pod to down an enemy MiG despite having no lead-computing gunsight.

In the process, the pilots began to realize that their combat experiences were diverging from that of their predecessors. In the past, Sabre pilots were instructed to be aggressive "tigers" and encouraged to charge headlong into packs of enemy MiGs with guns blazing hoping to score a lucky hit. In Vietnam, commanders like Olds and Blesse still demanded aggressive pilots, but it was no longer the distinguishing feature of a successful

fighter pilot.[254] A Phantom pilot wasn't going to hit anything if he didn't first remember to listen for the Sidewinder's "growl" before squeezing the trigger, nor would he have a chance if he couldn't first visualize the radar scan pattern in "gyro out" mode, so that his GIB could get a radar lock before he tried to fire off a Sparrow. Additionally, the Phantom crews determined that the best practice was rarely to send all four Phantoms barreling into a fight with the MiGs, but instead to send a pair of Phantoms running away to gain valuable separation before turning around to launch their missiles.

The 8th TFW's *Tactical Doctrine* manual from March 1967 tried to alert the Phantom pilots to the subtle shift. It offered a new definition of *fighter pilot*: "The individual who takes advantage of sound realistic training, who gathers, studies, evaluates, and applies all the information applicable to the mission, who takes advantage of the combat experience within the Wing, who has the forsight [*sic*], who is prepared for all possible contingencies, and who THINKS! These are the people who are effective and confident. These are 'Fighter Pilots!'"[255] Studying, evaluating, applying information—these were also terms historically associated more with scientists than with fighter pilots.

The Phantom, with its powerful radar mounted in the nose and its guided missiles slung beneath its belly and wings, was supposed to have simplified fighter aviation. Answering the call of the younger Korean aces, the advanced fire control system of the Phantom and the codified procedures for employing it were supposed to have transferred the difficult task of shooting down an enemy aircraft to the missile, and in the process helped democratize fighter aviation so that the nation would no longer have to rely solely on the skills of carefully screened and combat-seasoned "birdmen." However, it quickly became apparent that skilled pilots were still needed in the Phantom, and that those necessary skills could often only be developed in combat. Automation procedures and specified tactics "may be learned and recited verbatim," the 8th TFW's tactics manual noted, "but to be of use, this knowledge must be applied in the actual situation so that timing, coordination and teamwork can be acquired, and skills sharpened." As Olds observed, "just because you've got a more

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[254] Olds, Corona Ace Oral History Interview, 22; Blesse, Corona Ace Oral History Interview, 17; Ritchie, Oral History Interview, 24, 76; Ritchie, Corona Ace Oral History Interview, 31.

[255] *8th TFW Tactical Doctrine*, March 1967, v.

modern aircraft, you can't flit about the sky with any degree of impunity. [The enemy's] going to nail you."[256]

It was in this way that the Phantom pilots extinguished the notion that they were somehow "flying scientists" or merely black-boxed, button-pushing "missilemen." Instead, through their improvisation and craftsman-like tinkering with otherwise firmly established procedures, the Phantom pilots were able to rekindle the notion that, despite their missiles and their GIB, they were indeed the proper descendants of the great aviator aces of the past. The myth of the fighter pilot was still alive.

This continuing enchantment with the fighter pilot myth, however, had a pernicious side effect. When the tactics or procedures were not derived from the new technology but rather from the historical legacy of fighter aviation, the pilots proved exceedingly stubborn in adjusting them. For example, "fighting wing" had little utility in a battle between *missile*-wielding aircraft; it was designed for gun battles. Yet, because of the cultural significance that the formation position had assumed over the preceding decades, and specifically its role in grooming and "blooding" young fighter pilots, the more experienced pilots steadfastly refused to stray from the time-honored formation throughout much of the war.

The full implications of the system that the engineers and pilots had wrought with their Phantoms became blindingly apparent when the fighter pilots started trying to assign credit for aerial victories. In the past, it had been easy to extract the pilot from his aircraft for the purpose of bestowing glory and honor. In the Phantom, however, once the relevant components, including the GIB, had been aggregated in battle, it was nearly impossible to disaggregate and quantify each component's relevant contributions to victory. Even in the case of a gun-kill, in which the GIB had almost no role, it was still difficult to draw a distinction between the skill of the individual occupying the front seat and the performance of his GIB who first detected the enemy from miles away. Nor was it possible to separate the pilot's performance from that of his missiles; many a potential ace felt robbed of rightful glory because of a malfunctioning missile.

General Ryan's 1972 policy of awarding full credit to both Phantom crewmembers offered one means of addressing the controversy. But it did not resolve the underlying tension emerging in fighter aviation. In an increasingly complex environment with missiles

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[256] Ibid., 72; Olds, Oral History Interview, July 12, 1967, 46.

and radars and GIBs, in which the individual performance of the front seat pilot could no longer guarantee victory, what constituted heroic action? What feats were worthy of air combat glory, especially when the fighter pilots were spending the majority of their time not battling MiGs but dropping bombs?

There was another way to address the underlying tension; a return to Garros's original solution. The Air Force would adopt this strategy with its newest, custom-designed fighter, the F-15 Eagle. Designed as a retort to the Phantom experience in Vietnam, the Eagle was a powerful ideological statement for Air Force fighter pilots. Whereas the two-seat, missile-only, and multi-mission Phantom had compromised the elegant simplicity of the fighter pilot myth, the new Eagle would be a pure fighter, single-seat and single-mission. It would have a gun and it would be designed for maximum maneuverability in a close-range dogfight. But then a pair of missile and air combat tests conducted in 1977 altered the planned course of the Eagle and its pilots, and the fighter pilots once again had to face many of these same dilemmas.

Chapter 5

Eagles over Nellis: "A Fighter Pilot's Fighter"

What you fly and how you fly it isn't as important as what kind of missile you use and how you use it.... Either you fly with long-range kill capability, or you are going to operate at an unacceptable disadvantage.

—Major General Frederick C. "Boots" Blesse, USAF (Ret.), 1977

Historically, the skill and cunning of the men inside *the machines may often have been far more important in determining the outcomes of combat engagements than discrepancies in either the performance or weaponry of their opposing fighters*

—Major Barry D. Watts, USAF, 1977

On May 3, 1977, a US Air Force McDonnell Douglas F-15 Eagle rocketed down the runway, leaped into the air, and turned north. After a short ten-minute journey, the single pilot took up his assigned position over one corner of "Dogbone Lake," an unmistakable depression in the desert floor below that only rarely accumulated enough water to be worthy of its name. A few minutes later, the pilot started a sudden, hard turn toward the center of the lakebed and lit his afterburners. He had detected a small, twin-engine jet fighter maneuvering a few miles away. The F-15 pilot knew he needed to get a quick kill because the distant aircraft was equipped with a new version of a heat-seeking missile that was not restricted to being launched from near the target's tail—it could actually detect the heat generated by the air friction across the Eagle's nose, wings, and fuselage, giving it an *all-aspect*

capability. The new missile also had a much greater range than the AIM-9 Sidewinders used by the Americans a few years earlier.[1]

The Eagle was sporting its own advanced missiles for the mission, too. It carried a new version of the radar-guided Sparrow, the AIM-7F. Among its many improvements, the latest Sparrow had traded-out the vacuum tubes in the AIM-7E-2 for more reliable solid-state electronics, and the new missile also boasted an effective range almost twice that of the earlier "Dogfight Sparrow."[2] In addition to the Sparrow, the F-15 was also carrying a new, experimental IR-guided missile similar to that of the day's adversary. Peering through his HUD at his foe, the pilot in the F-15 verified the weapons parameters that were automatically calculated by his aircraft's central computer (CC). When the missile "shoot cue," a small triangle, appeared in the Eagle's HUD, the pilot pressed the red "pickle" button located on the top of his control stick. The F-15's Armament Control System (ACS) processed the firing request and within a second and a half, the missile was on its way.

The opposing pilot was an expert in Soviet air force tactics and he was flying an aircraft many considered comparable to the MiG-21 that had proven so troublesome in the skies over Vietnam years earlier. By the time Eagle pilot had pressed the pickle button, the enemy pilot had already detected the F-15 and was aggressively maneuvering his own aircraft for a missile shot. Although his aircraft lacked the Eagle's advertised greater-than-one thrust-to-weight ratio, it could still generate a very tight turn, which the enemy pilot immediately initiated to point his aircraft and his IR-guided missiles at the approaching F-15. A few seconds later, the enemy aircraft was hit by the Eagle's supersonic missile.

Unbeknownst to the F-15 pilot, though, his missile had arrived one second too late. The opposing pilot had already launched his own heat-seeking missile at the approaching Eagle. The two missiles passed each other, and after a few seconds, the F-15 pilot also received the dreaded radio call, "You're dead."

The engagement was an exercise, one of 463 trials flown by the Air Force's newest F-15 Eagles against a collection of F-5E Aggressor aircraft as part of the joint Air Force-Navy AIMVAL test. No actual missiles had been fired in the desert north of Nellis AFB, but

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[1] "No-Win War at Dogbone Lake"; Kaylor, "Mock Dogfights Test Latest Jet Fighters"; Tissot and Hildreth, *AIMVAL Final Report, Vol. 1*; Everson, *AIMVAL Final Report*. McDonnell Aircraft merged with Douglas Aircraft in April 1967.

[2] Mathis, "F-15 Air Superiority Fighter"; Wells, "Sparrow Missile Program Review," 5000–13.

each pilot had performed every step in their cockpit just as if they were carrying real missiles. The exception was that instead of looking for explosions in the sky to alert them of victory (or danger), a revolutionary new training and evaluation tool, ACMI, was used to collect and assess the missile data. Test officials on the ground watched the engagements unfold in real-time, and when the ACMI computers predicted a missile kill, the observers radioed the appropriate aircraft.[3]

The two opposing aircraft for the day's mission were strikingly different, each representing a distinct design philosophy. The Northrop F-5E was developed as an extremely "agile" but low-cost fighter airplane. Its designers shunned the complex electronic black boxes that had been crammed into the earlier Phantom and newer Eagle in favor of simplicity of operation and maintenance. Hence, although the F-5E was equipped with a small radar, it only carried a cannon and IR-guided missiles as armament; no radar-guided missiles. It was also small like a Soviet MiG-21 and its turning performance in a dogfight was considered comparable, which made it ideal for use in the Air Force's "Soviet" Aggressor squadrons (figure 5.1).[4]

Figure 5.1. Air Force F-5E Aggressors.
(Source: NMUSAF)

The F-15, in contrast, was immense (figure 5.2). A single vertical tail on the F-15 was nearly the size of a MiG-21's wing. The Eagle's wingspan was 65 percent larger than the F-5's and the Eagle's fuselage stretched almost twenty-feet longer. At the front of the Eagle, a huge radome shielded the largest air-to-air radar yet developed for a fighter airplane. But, like the F-5, the Eagle had only a single seat in the cockpit, which meant that the F-15 also

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[3] Everson, *AIMVAL Final Report*, 5–7, 13–14; Tissot and Hildreth, *AIMVAL Final Report, Vol. 1*, III–1–2. ACMI will be discussed in detail later in this chapter.

[4] Burns, "Aggressively Speaking"; Glasser, "Research, Development, Test, and Evaluation," 358–59; Currie, "Statement of the Director of Defense Research and Engineering," 455–56; "Research, Development, Test, and Evaluation," 1022–23; Nabors, "Aggressor Squadron Briefing," 4907–20; Knight, Oral History Interview, 208; Anderegg, *Sierra Hotel*, 71–88; Michel, "Revolt of the Majors"; "New Planes Designated for Nellis"; "Nellis AFB Squadron Get First F-5E Tiger Fighters"; "'Operation Red Flag' Studies"; Hillinger, "'Russian Squadrons' Fly Mock Battles"; Galatz, "Old West Scene." The Aggressor squadrons, which some deemed "the most significant item in the development of modern air-to-air combat capability," consisted of specially trained Air Force pilots who mimicked Soviet tactics during training events with other Air Force units. The Aggressors' F-5E aircraft, initially developed by the Air Force as a low-cost export fighter but later adopted by the Aggressors to replace their original, under-powered, two-seat T-38s, simulated the Soviets' MiG-21 fighter.

needed an array of complex, electronic gadgetry to help the pilot manage the powerful radar and multi-missile fire control systems. Engine operation in the F-15 was also complex but largely automated: an air data computer automatically calibrated the position of the hydraulically actuated, variable geometry engine inlets based on air temperature and aircraft speed to ensure proper airflow to the aircraft's pair of Pratt & Whitney F100 engines. All told, the F-15 embodied cutting-edge technology, which was aptly reflected in its nearly $10.5 million dollar unit cost—more than four times that of the F-5E.[5]

Figure 5.2. Air Force F-15 Eagle.
Four AIM-7 Sparrows are mounted along the underside of the Eagle; four AIM-9 Sidewinders are mounted under the wings, two on each side. (Source: NMUSAF)

The F-15 Eagle was the Air Force's first attempt at building a dedicated air superiority fighter since the F-86 Sabre nearly forty-years earlier. For the pilots, their new "fighter pilot's fighter" promised to restore the sanctity of the fighter pilot myth that had been tarnished by the two-seat Phantom, a "really ugly airplane," in the words of Welch, "that didn't do anything really, really well."[6] It wasn't just the return to a single-seat cockpit, either. The F-15, despite its powerful radar and standard complement of four AIM-7F Sparrows, was not designed to be a long-range, missile-hurling interceptor like the Phantom. Rather, it was designed to be a dogfighter like the F-5E, optimized for aggressive

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[5] Anderegg, *Sierra Hotel*, 150; *F-15 Eagle*, 2; *USAF F-15 Fighter Summary*, 12. Cost figures for aircraft are always troublesome due to changing requirements, procurement schedules, etc. The F-15 and F-5E costs cited are based on Air Force Congressional testimony delivered March 13, 1974: at that time, the F-15 unit program cost was $10.5 million; the F-5E had a unit flyaway cost of $2.646 million. Bellis, "F-15 Program Review," 4267–68; Stringer, "F-5 Program Review," 4300. The Eagle's "complex inlet" mechanism drew a wary eye from Air Force engineers when it was first proposed; *SSAC Proposal Analysis*, 8. The F-15's F100 engines experienced significant problems early in the program. Sokol remembered, "They'd bang. They'd pop. They'd stall. They'd stag[nate]." Sokol, interview. The engine problems were generally not related to the inlets, but to the fuel control systems; see information on the early engine problems in Lewis, *History of the F-15 Eagle*, 94–101; Sullivan, *History of the 58th Tactical Fighter Training Wing, Apr - Jun 1975*, 36–37, 65–71; *1 TFW Aerial Attack Manual, Vol. 1*, 66.

[6] Welch, interview, October 1, 2013; Davies, *F-15C Eagle Units in Combat*, 7; Hoag, "Superfighter," 21. The "fighter pilot's fighter" was an oft-used expression for the F-15. For example, Meyer called the F-15 "a fighter pilot's fighter—a modern-day version of the F-86 MiG-killer." Meyer, "Air Superiority into the 1980s," 43. See also Osterhout, Berdan, and Gordon, "F-15 Briefing Script," slide 3; Ryan, Oral History Interview, 44; "F-15: A Fighter Pilot's Fighter"; "Four Reasons Why the F-15 Is a Fighter Pilot's Fighter"; Brown, "Fighter Pilot's Fighter Plane."

maneuvering. But, whereas the F-5E could only match the performance of the MiG-21, the F-15 was built so that it could handedly out-turn and out-power any current or future Soviet fighter. The Air Force's plan to outfit the Eagle with a new, more-powerful 25-mm air-to-air cannon was one technological manifestation of the design emphasis on close-combat. So too was the Eagle's HUD and HOTAS systems, which would allow the pilot to keep "his eyes on the target and his hands on the stick and throttle, a significant advantage in the dogfight scenario," according to one Air Force press release. Similarly, the Eagle's large bubble canopy was more reminiscent of that of the F-86 Sabre than the F-4 Phantom. Like Evans decades earlier, the next generation of Air Force air superiority pilots could look over their shoulder, down the Eagle's smooth leading edge, and "imagine all sorts of exciting possibilities."[7]

The results from the AIMVAL and ACEVAL tests, "the biggest fighter-plane shoot-out in peacetime history," upset the Eagle pilots' plans. The F-5E with its new all-aspect, IR-guided missile proved exceptionally lethal to the Eagle in the close-range environment. The Eagle scored several victories, too, but not at a rate as lopsided as many had hoped. In the test scenarios, it didn't matter that the F-15 could easily out-power the F-5E, or that the Eagle pilot had a variety of short-range, radar auto acquisition modes available to him with the mere twitch of his right thumb. All of the Eagle's technological advantages in the short-range environment could be quickly negated if the opposing pilot simply saw the F-15, turned to point at it, and squeezed off an IR-guided missile just a second before he was called "dead." In one notorious engagement, four F-15s squared off against four F-5Es and 112-seconds later, everybody was dead, the last two pyrrhic victories coming like those on the third of May when opposing missiles figuratively passed each other in the sky. The infamous four-against-four engagement became known as the "Towering Inferno" mission, a reference to the 1974 Oscar-winning disaster film starring Steve McQueen and Paul Newman, because, in the words of one analyst, "everybody died." The mission wasn't that abnormal, though. One news report summarized the tests' central finding: "Once a pilot gets

[7] Evans, *Sabre Jets Over Korea*, 234; *F-15 Eagle Fact Sheet*, February 1973, 2; Osterhout, Berdan, and Gordon, "F-15 Briefing Script," slide 9; Werrell, *Chasing the Silver Bullet*, 70.

into a dogfight, or even comes within range of his adversary's missiles, both pilots are likely to die."[8]

Blesse, who retired as a major general two years prior to AIMVAL-ACEVAL, was invited to observe the trials at Nellis. Based on his brief visit during AIMVAL, he concluded that the tests had the potential to "produce the first real change in aerial tactics since World War I." Novel tactics were needed, Blesse believed, to exploit the promise of the new technologies showcased in AIMVAL, such as "launch-and-leave missiles ... and better means of target identification." The critical lesson was that it wouldn't matter anymore "what you fly and how you fly it," Blesse opined, only whether or not "you fly with long-range kill capability." It was a curious assessment coming from a combat ace that earlier in his career fought vigorously against the "missile people" lurking in the halls of the Pentagon, and who later led the charge to equip the F-4C with an interim air-to-air gun capability. Blesse's remarks on AIMVAL were qualified by the fact that he was then working as the special assistant to the Chairman and President of Grumman Aerospace, the manufacturer of the Navy's F-14 Tomcat which was also undergoing testing during AIMVAL-ACEVAL. Still, coming from the author of "No Guts, No Glory," his prediction that "Tomorrow's jet ace no longer will have to see an enemy aircraft to destroy it" was somewhat disconcerting to the next generation of Air Force fighter pilots.[9] While Blesse's assessment accorded with the Air Force's and Navy's plans to outfit their fleets with high-technology fighters like the F-15 and F-14, it also seemed to belie the central element of the historic fighter pilot myth—that it was not technology but the skill of the heroic aviator inside his craft that determined victory.

Several challenged Blesse's assertions. Some of the critiques came from industry, especially those that were trying to market the simple and cheap F-5E as a viable alternative to the more exquisite Eagle and Tomcat. However, several former Vietnam F-4 pilots also rebuffed Blesse's claims, explaining that they had heard a similar line of reasoning only a

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[8] "No-Win War at Dogbone Lake," 56; Guillermin, *Towering Inferno*; Dvorchak, interview; Sparks, interview; Anderegg, *Sierra Hotel*, 159. Some news reports mistakenly termed the infamous four-against-four engagement the "Towering Infernal"; see Kaylor, "Mock Dogfights Test Latest Jet Fighters," 12A; "Air Force Tried out Controversial Planes." The conclusions reached in "No-Win War at Dogbone Lake" became a topic of discussion during Congressional testimony; see Fay, "AIMVAL-ACEVAL Program Review," 1978, 5221–23.

[9] Blesse, "Changing World of Air Combat," 34, 37; "No-Win War at Dogbone Lake," 57; Blesse, Corona Ace Oral History Interview, 72–74. Blesse noted, "I, myself, would not like to try to become a jet ace again without those capabilities."

decade earlier. Major Barry Watts was one such Phantom aviator. Currently on assignment teaching philosophy at the Air Force Academy, Watts accused Blesse of assuming that "aircraft performance" was and would always be the "determining factor in aerial battle." Invoking Korean War statistics that emphasized the importance of the ace, Watts argued that it wasn't the machinery, but "the skill and cunning of the *men inside* the machines" that "historically" determined victory.[10]

The controversy over the F-15, AIMVAL-ACEVAL, and advanced missile weaponry therefore reflected the on-going conflict between the "great machine" and "great pilot" narratives. As usual, rather than recognizing their complementary elements, the two narratives were placed in competition with each other. But, there could be no "great machine" unless there were pilots or operators trained to employ Blesse's new missiles. Similarly, Watts's "great pilots" would continue to need "skill and cunning," but their skills were no longer the same as those required earlier in Korea or even in Vietnam. Instead, both pilot and machine would have to evolve together if they were to function as an effective combat system in the future.

In assessing the F-15's impact on the changing patterns of human-machine interaction within fighter aviation, I break from the pattern of the prior chapters and focus on the AIMVAL-ACEVAL *tests* rather than a wartime experience. This shift is necessary because the first combat test of the American F-15s did not come until 1991 during Desert Storm, but classification issues prohibit me from extending this project's analysis to that timeframe.[11] Complicating matters, much of the raw AIMVAL-ACEVAL test data also remains shrouded from public view due to lingering security concerns. However, based on extracted, unclassified reporting and several participant interviews, it is clear that the two tests marked a significant turning point in the development of the F-15's technologies and its aircrews. Both aircraft and pilot entered AIMVAL-ACEVAL focused primarily on close-

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[10] Watts, "Changing World of Air Combat." Emphasis in original. Watts complained that *"the capability to fight in close, relying on aircraft performance and the traditional fighter maneuvers, is still not necessarily antiquated.*... Even if you yourself can shoot opponents twenty or thirty miles away, in crowded skies you are still going to have to be able to handle close-in attacks from two or three." On the Korean War, Watts noted that "a mere 4.8% of the 800 Sabre pilots who flew at least twenty-five counterair missions are credited with no less than 38.2% of the kills."

[11] After the F-15C was fielded in 1979, the original F-15 model became known as the F-15A, and the original two-seat TF-15 was renamed the F-15B. Since the F-15C is still in active service today, many of its manuals remain classified or have limited access.

range air combat. They emerged with fresh requirements for improved technologies, tactics, and procedures that would allow both to excel not just at dogfighting, but more importantly at long-range air combat. It was almost a 180-degree reversal of that experienced by the Phantoms and its aircrews years earlier in Vietnam.

I open this chapter with an analysis of what the F-15 and its technologies were supposed to be—in many ways, a direct retort to the trying experience of flying F-4C Phantoms in combat over Vietnam. From its first conceptualization, the Eagle was modeled after the F-86 Sabre, a single-mission, single-seat dogfighter. However, the fighter pilots also wanted their new fighter to be capable of employing the service's most advanced air-to-air weapon, the AIM-7 Sparrow. This meant that the Eagle would also need a powerful radar to support the Sparrow, akin to that which outfitted the Phantom earlier. An advanced radar would additionally aid the pilots as they were maneuvering into an advantageous position prior to the eventual dogfight. But the complex radar and fire control systems also needed to be capable of being operated by only a single pilot. It was a tall order, which the F-15's engineers planned to address by incorporating further automation and improved cockpit mechanization into their design so as to simplify the pilot's tasks, especially when he was engaged in a close-range battle. It was this design emphasis that led many to tout the new F-15 as the "fighter pilot's fighter."

However, when the Eagle pilots began exercising their new fighter in simulated air combat like AIMVAL-ACEVAL, they experienced a rude awakening. Despite all their planning and practicing, they discovered that their best chances at success and survival came when they purposefully avoided a swirling dogfight and instead relied on the F-15's long-range capabilities. The sudden shift necessitated the rapid development of new radar procedures and intercept tactics designed to maximize the Eagle's offensive potential. It also required the pilots to finally forsake fighting wing with its pre-designated formation responsibilities in favor of a more flexible and mutually beneficial arrangement. Collectively, these dramatic changes demanded new skills of the pilots, and unlike in the past, these skills could not be acquired simply by spending more hours in the jet; they needed to be cultivated and taught through intense study and post-mission evaluation. The final section of this chapter investigates these associated changes and their impact on the experience of flying the F-15. Simply phrased, could the Eagle still be the "fighter pilot's fighter" if it was no longer going to be primarily a dogfighter?

A *Pure* Air-to-Air Fighter

Most aviation historians trace the development of the F-15 Eagle to a nondescript set of meetings convened in fall 1964. Major General Arthur Agan, a veteran fighter pilot from World War II who had recently completed an assignment as a SAGE division commander, arrived at the Pentagon earlier that summer to serve as the Air Force's Director of Plans. Agan harbored strong opinions regarding what was a fighter aircraft and what wasn't. His standard was simple, "When you get a fighter with a bomb on it, it's a bomber, not a fighter." Hence, in Agan's estimation, his service's new multi-role F-4C was obviously a bomber, and he considered the "big heavy clunker" TFX an attack airplane worthy of an "A-111" designation as opposed to the "F-111" that it received. Moreover, Agan was furious that the analysts in the Pentagon kept passing him reports and war plans that included the caveat, "Assume air superiority." Based on his experiences battling the *Luftwaffe* over Europe, Agan considered the caveat tantamount to "assuming you've won the war too." He later remarked that he wanted desperately to "bring somebody's attention to the fact that we [in the Air Force] weren't thinking about beating enemy airplanes in the air with airplanes."[12]

Agan chartered a small group of recognized air combat experts to help him that fall. Thyng, the combined double ace from World War II and Korea and now a brigadier general, was asked to chair it. Gabreski was invited to participate, as was his fellow World War II triple ace William Dunham. Korean ace Winton Marshall was also a member, along with a few other up-and-coming fighter pilots like John Burns. The subsequent report was rather informal and "generalized," but it eventually had the desired effect, Agan said, of getting "someone to listen and to then get a competent effort started toward putting together a requirement for an air fighter." At first, however, the civilian budgeters in the Pentagon ignored the aces' report. The CSAF, the famed bomber general Curtis LeMay, also showed

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[12] Werrell, *Chasing the Silver Bullet*, 60; Neufeld, *F-15 Eagle*; "Lieutenant General Arthur C. Agan"; Agan, Oral History Interview, February 1970, 11; Agan, Oral History Interview, October 2, 1973, 14–16, 32; Myers, Oral History Interview, 9–10. The "F" designation was reserved for fighters; the "A" designation was used for ground attack aircraft. Neufeld's original study of the F-15 was classified. It has since been declassified, but an original unclassified, "sanitized copy" was also produced in 1974. All references herein are to the original classified version.

little enthusiasm for its findings. But when General John McConnell replaced LeMay a few months later in February 1965, the report resurfaced.[13]

McConnell had spent many years in SAC, once serving as the command's vice commander, but he had also spent time flying fighters in the Pacific theater during World War II. McConnell served as LeMay's vice prior to becoming the CSAF, so he was aware of the aces' report and its initial poor reception within the Pentagon. He was also aware of another Air Force study completed earlier by Lieutenant Colonel John Bohn Jr. which supported Agan's arguments. Bohn's report specifically challenged "the folly of assuming air superiority," especially in light of the new class of Soviet interceptors and fighters then thought under development. The sudden loss of the pair of F-105s to North Vietnamese MiG-17s on April 4, 1965, the day the Phantoms from the 45th TFS departed MacDill AFB for Ubon RTAFB, offered immediate credence to Agan's and Bohn's concerns. McConnell responded in May by issuing a "policy statement," likely drafted by Agan, that articulated the "Air Force's requirement 'to win air superiority.'" In a service that hadn't seriously considered achieving air superiority through air battle in several decades, the statement was considered a major coup for Agan and his acolytes. By the time of McConnell's announcement, however, an internal study had already been initiated to develop the requirements for a new Air Force fighter known as the F-X. In December 1965, a call for proposals and design studies went out to industry.[14]

It would take another three years for the F-X design to stabilize as "a single-pilot, twin-engine turbofan-powered aircraft with a 44,500-lb takeoff gross weight," that, when combined "with its avionics and weapons," was intended to "be superior in air combat ... both in close-in, visual encounters and in standoff or all-weather encounters."[15] In the interim, the F-X design experienced considerable turmoil, at times taking shape as a small,

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[13] Agan, Oral History Interview, October 2, 1973, 7, 17, 22, 36; Burns, Oral History Interview, March 22, 1973, 1–4; Georgi, Oral History Interview, 14–15; Myers, Oral History Interview, 31; Neufeld, *F-15 Eagle*, 7–8; Werrell, *Chasing the Silver Bullet*, 60–61.

[14] Agan, Oral History Interview, October 2, 1973, 39; Burns, Oral History Interview, March 22, 1973, 13–17, 24–25, 29–30; Myers, Oral History Interview, 25–26; "General John P. McConnell"; Neufeld, *F-15 Eagle*, 8–11, 17; Werrell, *Chasing the Silver Bullet*, 61–62; Futrell, *Ideas, Concepts, Doctrine, 1907-1960*, 301; Michel, "Revolt of the Majors," 72; Slay, "Tactical Air Programs," 4811. For years, the service had emphasized destroying enemy fighters "on the ground and in [their] nest" using tactical nuclear bombs. The Bohn study recommended "a mix of high- and low-cost aircraft as the most economical way to strengthen the tactical force," which would become a staple of Air Force procurement strategy for the next several decades.

[15] O'Donohue, "Development Concept Paper," 1. On the writing of the "Development concept Paper," see Rhodarmer, Oral History Interview.

20,000-pound lightweight fighter focused on maneuverability, a 60,000-pound, variable-sweep wing, podded-engine, multi-crew, multi-role fighter, and almost every other variant in between. A letter jointly signed by the Air Force's tactical air commanders at TAC, PACAF, and USAFE (United States Air Forces in Europe) urged McConnell in February 1966 to avoid the temptation to transform the Air Force's next fighter into a multi-role one like the F-4. Although the "twelve star letter," so named because three four-star generals had signed it, failed to immediately resolve the design controversy, the generals ultimately got their wish.[16] On December 23, 1969, the Air Force announced that McDonnell Douglas had won the contract for the "F-15 advanced tactical fighter aircraft." The new fighter, the public affairs officials announced, was "designed specifically as an air superiority weapon system."[17]

When the first F-15 taxied out from the McDonnell Douglas factory in St. Louis on June 26, 1972, its "engines keening like a banshee," Mrs. Iris Rose Hansen, wife of the assistant Secretary of the Air Force, christened the new jet "Eagle, and may you reign supreme in your domain." Hansen's husband, Grant, remarked at the ceremony that the F-15 would "outclimb, outmaneuver and outaccelerate any fighter threat in existence or on the horizon."[18] Capturing the fighter pilots excitement for their new fighter, Momyer, now serving as the commander of TAC, described "the F-15 as having 'more potential than a pilot can psychologically take.'"[19] The Air Force had collectively pinned its air superiority hopes on the Eagle. The single-seat cockpit was certainly part of the Eagle's appeal to its potential future pilots, as was its single mission focus. Yet, even at the roll-out, there was still some uncertainty as to how the Eagle would fulfill its air superiority mission and whether a single pilot, aided by significant automation, could sufficiently operate the complex aircraft in a hostile environment.

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[16] Burns, Oral History Interview, March 22, 1973, 33; Kent, Oral History Interview, 7–9; Neufeld, *F-15 Eagle*, 12–13, 17–18; Werrell, *Chasing the Silver Bullet*, 62–66; Gillespie, "Mission Emphasis," 183–90.

[17] The announcement was broadcast service-wide via message traffic: USAF to ALMAJCOM, December 24, 1969. See also Neufeld, *F-15 Eagle*, 44, 48; Werrell, *Chasing the Silver Bullet*, 66. McDonnell Douglas won the competition handedly, besting its nearest rival by more than 10 percent in the scoring metrics; see *SSAC Proposal Analysis*, 17. On McDonnell Douglas's submission, initially identified as its "Model 199," see *F-15 Eagle*.

[18] Middleton, "Air Force Unveils Fighter," 1; Lewis, *History of the F-15 Eagle*, 35.

[19] "F-15 Rolls Out at St. Louis," 11.

A Single Mission

The refrain "not a pound for air-to-ground" that guided the F-15 design allowed the service to develop an uncompromising air-to-air fighter that was reminiscent of the iconic Sabre and the heyday of the fighter pilot, air combat, and ten-to-one kill ratios. However, the single-minded focus on air superiority also served important political objectives for the Air Force in justifying its new fighter, and those political considerations in turn played a critical role in shaping the design and intended close-combat employment scheme of the Air Force's newest fighter. Admittedly, many in the Air Force wanted a maneuverable fighter capable of close-range dogfighting, but most importantly, *nobody* in the Air Force wanted their F-X to be derailed by the Navy.

The first step was to sell the different Air Force communities on an F-X configured primarily for air-to-air combat. The "twelve-star" letter from early 1966 helped, as did Agan's earlier aces' study. However, McConnell also took deliberate steps to smooth the path. In late 1965, under pressure from McNamara to select either the F-5 or the Navy's A-7 as the service's next close air support fighter, the CSAF opted for the humiliation of having yet another Navy-designed aircraft enter the Air Force fleet. The advantage was that few would dare consider the A-7 Corsair a viable air-to-air fighter (figure 5.3), whereas there were some that were already positioning the F-5 for that role. Moreover, the selection of the A-7 helped validate the Air Force's requirement for a new air superiority aircraft. A June 1965 study conducted by Colonel Bruce Hinton, the same officer who had led the F-86s into Kimpo and scored the first MiG kill, and the earlier Bohn study had both concluded that the A-7 was a better close air support aircraft than the F-5, but only if the Air Force could guarantee sufficient air cover to ensure that the A-7 would be unmolested by enemy aircraft. Agan explained that once the A-7 decision had been made, the "F-X could now be justified as a 'more sophisticated, higher performance aircraft, … an air superiority replacement for the F-4.'"[20]

Figure 5.3. Air Force A-7D.
(Source: NMUSAF)

[20] Hildreth, Oral History Interview, 59–63; Burns, Oral History Interview, March 22, 1973, 25–26; Kent, Oral History Interview, 3, 6; Agan, Oral History Interview, October 2, 1973, 12–13, 18–21; Neufeld, *F-15 Eagle*, 10,

Furthermore, with the majority of the service's tactical aircraft adept at ground attack but woefully unprepared for air-to-air battle, McConnell was in a favorable position to argue passionately for the uncompromising F-X. The emergence of the Mach 2.9 Soviet MiG-25 Foxbat at the Domodedovo Air Show in 1967, which appeared to out-class any American fighter aircraft, also helped validate the Air Force's requirements for an air-to-air F-X. Intra-service obstacles still remained, however. Some officials considered the planned aircraft a niche asset, "nice to have … but not essential." Others argued that the F-X represented an attempt to assuage the fighter pilots and their "romantic attachment to air-to-air combat, a kind of 'knights of the air' syndrome." McConnell alluded to the dissension within the service in his testimony before the Senate Armed Services Committee in May 1968, explaining: "We had a very difficult time in satisfying all the people who had to be satisfied as to what the F-X was going to be.... There were a lot of people in the Air Force who wanted to make the F-X into another F-4 type of aircraft. We finally decided—and I hope there is no one who still disagrees—that this aircraft is going to be an air superiority fighter."[21]

Despite McConnell's testimony and the accompanying air-to-air rhetoric, the emerging F-15 still retained a "significant" air-to-ground capability, and the Air Force planned on taking advantage of it. As one September 1968 document noted, after McConnell's Senate testimony, the F-X's "potential use in air-to-ground missions, once air superiority is attained, cannot be neglected."[22] However, any air-to-ground provisions were not allowed to adversely affect the aircraft's air-to-air performance; that was the intent behind the "not a pound for air-to-ground" mantra. Hence, when McDonnell Douglas

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13–14; Werrell, *Chasing the Silver Bullet*, 62–66; Gillespie, "Mission Emphasis," 207. Hildreth was TAC's project officer for the A-7.

[21] Quoted in Neufeld, *F-15 Eagle*, 25–26, 66–68; McGough, Oral History Interview, 6–8; Burns, Oral History Interview, March 22, 1973, 34; Rhodarmer, Oral History Interview, 33–34; Werrell, *Chasing the Silver Bullet*, 65. Developing procedures to deal with the Foxbat's impressive altitude and speed performance became a major area of emphasis for F-15 designers and tacticians. See discussions in: Osterhout, Berdan, and Gordon, "F-15 Briefing Script," slides 29–33; *F-15 Eagle*, vi–vii. During testing, the F-15 practiced intercepts against "a target flying at Mach 2.8 to 3.0 at 80,000 feet" to validate its expected performance and tactics against the Foxbat; see Flood and Rodero, *F-15 Initial Operational Test and Evaluation—Air-to-Air*, A–94–101. The fact that the F-15 was the only American fighter deemed capable of tangling with the Foxbat became a source of pride for the engineers at McDonnell Douglas and the Eagle's pilots; one advertisement noted: "The USAF F-15, the Fighter Pilot's Fighter, Won't Be Out-Foxed in the Air Battle Arena."

[22] O'Donohue, "Development Concept Paper," 5. Another report from August 1970 noted that "many F-15 aircraft characteristics which are essential to air-to-air combat are equally as important to air-to-ground combat." Holbury, *Concept of Operations for the F-15*, 13. See also Kent, Oral History Interview, 6–7.

submitted its proposal for the F-15 contract in mid-1969, an advertised feature of their Model 199 was that its "*air-to-air weapons can be launched with air-to-ground weapons and tanks aboard.*"[23] Later, after Air Force pilots had put the F-15 through the ringer during testing at Edward AFB, California, they concluded that the Eagle "was an effective air-to-ground weapons platform."[24] But, the Air Force never developed a clear concept of how the F-15 would actually be *used* in an air-to-ground role alongside other Air Force tactical aircraft, and in light of the tactical and doctrinal concerns, the CSAF in October 1975 halted further tactics development and employment of the F-15 in air-to-ground scenarios.[25]

While the service had essentially settled on the F-X as an air-to-air fighter by 1968, it had not necessarily decided on the primary means by which the F-X would achieve air superiority: either through long-range missile attacks or in short-range air combat. A bout of inter-service rivalry with the Navy would steer the F-X toward the latter. When the Air Force began work on its F-X, the Navy was simultaneously developing its own replacement for its F-4 Phantoms. After some fits and starts, the Navy eventually settled on a VFX-1 design which would later evolve into the Grumman F-14 Tomcat (figure 5.4). The Navy's large, twin-engine fighter would, like the Air Force's F-X, focus solely on air-to-air combat. However, the Navy also emphasized long loiter times and super long-range missiles to fulfill the requirements of the fleet defense mission. Variable geometry wings and the massive AIM-54 Phoenix missile, along with a second seat for the RIO who would be needed to operate the radar and support employment of the 100-mile range Phoenix missiles, consequently became staples of the 70,000-pound VFX-1 design.[26]

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[23] *F-15 Eagle*, 2, 9. Emphasis in original.

[24] Flood and Rodero, *F-15 Initial Operational Test and Evaluation—Air-to-Ground*, v.

[25] Mathis to AFSC/SDNJ, "F-15 Attack Version"; Chain to TAC/DOO and CSAF/XOO, "TAC 1 TFW DOC"; Welch, interview, July 10, 2012; Lewis, *History of the F-15 Eagle*, 72, 83–84; Gillespie, "Mission Emphasis," 215–16. See other references to the F-15's ground attack potential in: Holbury, *Concept of Operations for the F-15*, 13–15; *USAF F-15 Fighter Summary*, 15; *F-15 Eagle Fact Sheet*, 1975. The first F-15 pilots converting from other TAC fighters all received training in ground attack: sixteen hours of academics and three sorties. In contrast, they received forty-two hours of academics and thirteen sorties on "aerial attack." *USAF Conversion Course, F-15.*

[26] O'Donohue, "Development Concept Paper," 5–7; Neufeld, *F-15 Eagle*, 23–24, 26–27, 33, 66–68; Rhodarmer, Oral History Interview, 19–20. The variable geometry wings facilitated the F-14's long loiter-quick sprint capability. The Tomcat could carry up to six Phoenix missiles, but with each pair of missiles weighing substantially more than a Volkswagen Beetle, aircrews usually only carried four Phoenixes under the fuselage. The F-14-Phoenix combination was advertised as possessing a "multi-shot" capability against distant targets, whereby a single F-14 could launch multiple Phoenix missiles against multiple targets, but the targets all needed to be flying within a small, prescribed volume of airspace. It was understood that a dedicated RIO would be

When they first embarked on their F-X and VFX programs, the two services had hoped to avoid the commonality push within the Pentagon that had led to the earlier TFX (F-111) debacle. After arguing their positions for nearly a full year beginning in May 1966, they finally convinced the civilian leadership in the Pentagon that "development of a single, bi-service fighter" was "neither feasible nor desirable." However, the handshake deal did not stop others within Congress or the public from questioning why the Air Force and Navy were both developing their own twin-engine, twin-tail, air superiority aircraft. With the Navy's VFX contract preceding the Air Force's F-15 contract by almost a full year, the Air Force raced to both justify its platform and differentiate it from the Navy's VFX.[27]

Figure 5.4. Navy F-14 Tomcat.
The F-14 is launching the AIM-54 Phoenix. An AIM-7 Sparrow and an AIM-9 Sidewinder are also visible under the wing alongside the engine intake. (Source: Naval Aviation Museum, Robert L. Lawson Collection)

A series of internal talking papers produced within Air Force Systems Command in 1969 and 1970 shed light on the Air Force's strategy. The critical distinction was to be the F-15's superior maneuverability, a product of rigorous aircraft design and calculated trade-offs made according to Colonel John Boyd's Energy-Maneuverability (E-M) analyses.[28] As one

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required to orchestrate the "multi-shot" targeting, especially when encountering the ECM that was expected to be used by the likely Soviet bomber targets. Grumman won the contract for the F-14 in February 1969.

[27] "Talking Paper on 'Dr. DuBridge Letter to Mr. Packard'"; Neufeld, *F-15 Eagle*, 23–24; Rhodarmer, Oral History Interview, 5, 17–23; Flax, Oral History Interview, 26–28; Werrell, *Chasing the Silver Bullet*, 63–65.

[28] O'Donohue, "Development Concept Paper," 5; Hammond, *Mind of War*, 51–82; Coram, *Boyd*, 135–153, 188–231; Neufeld, *F-15 Eagle*, 18–19, 27; Werrell, *Chasing the Silver Bullet*, 60–61, 63–65; Gillespie, "Mission Emphasis," 208–12; Agan, Oral History Interview, October 2, 1973, 10; Boyd, Oral History Interview; Boyd and Christie, "Expanded Maneuverability Theory"; Flax, Oral History Interview, 19–20; Georgi, Oral History Interview, 11–12; Myers, Oral History Interview, 15, 22–24, 29–30, 38; Welch, Oral History Interview, 171; Welch, interview, July 10, 2012. Many would eventually credit Boyd with the superior design and maneuverability of the F-15. Neubeck described Boyd's E-M theories as "a revolutionary analytical technique that permitted fighter 'jocks' to communicate with engineers." Agan's aces' study had worked with Boyd. Welch, working in the Air Force's Studies and Analyses branch at the time, was able to incorporate Boyd's E-M calculations into his TAC Avenger air combat simulation program, which helped quantify the advantages of the F-X and allowed it to gain additional support within the service. (On TAC Avenger, see Witze, "TAC AVENGER Is Out to Win"; Kent, Oral History Interview, 11–15; Welch, Oral History Interview, 127–28.)

Of note, O'Donohue argued in 1968 that "there is no substitute for fighter maneuverability, when evading a tail attack by the enemy, or when trying to gain an advantageous position for a kill, in close combat." Hence, as Gillespie noted, the emphasis on close combat was essentially baked into the F-15 design by the time the contract was awarded to McDonnell Douglas in 1969. However, I posit that the inter-service rivalry hardened

talking paper explained, the F-14 enjoyed the luxury of flying fleet defense, which would allow it to stay near its carriers and in otherwise benign waters. Furthermore, the F-14 didn't need to be exceptionally maneuverable to lob its long-range Phoenix missiles at far-off targets. The F-15, in contrast, would participate in "offensive missions in an enemy's air space," which would place the F-15 under constant threat of an otherwise undetected attack. "Our fighters," the F-15 proponents therefore argued, "must be able to quickly outmaneuver the enemy to gain the necessary advantage and make the kill. Superior maneuvering capability is the key to success and, therefore, the overriding factor that has been followed in designing the F-15 as a single-purpose, highly specialized aircraft for the fighter versus fighter role."[29]

In emphasizing these maneuverability requirements as a means to differentiate its Eagle from the Navy's Tomcat, the Air Force also steered the aircraft's technologies and its tactics toward assisting the Eagle pilot primarily in close-range battles. The significance of the gun in the F-15 was one manifestation of this "fighter versus fighter" emphasis. As noted in the previous chapter, the gun exerted a powerful psychological effect over Air Force fighter pilots. One pilot described it as the "fighter pilot syndrome"—"If I only had a gun, I could shoot down everyone." After having labored to get a gun first *onto* the F-4C/D and then *into* the F-4E, it was probably a foregone conclusion that the service's new F-15 would also have an internal gun. One F-15 briefing delivered to Momyer in 1971 declared, "The gun is a mandatory item for an air superiority fighter. It is absolutely essential that we have that instantaneous, unjammable, close range capability."[30]

But, the Air Force didn't want just any gun for its new F-X, it wanted a new and improved air-to-air gun that had a "higher muzzle velocity, flatter bullet trajectory and greater kill capability" than the 20-mm General Electric M-61 Gatling guns currently in use. The new GAU-7/A 25-mm gun under development was supposed to use a caseless round to

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the Air Force's position and specifically contributed to the Eagles' cockpit design and its optimization for the close-combat environment.

[29] "Talking Paper on 'Dr. DuBridge Letter to Mr. Packard'"; "Suitability of the F-14B for the F-15 Mission"; "Why TAC Cannot Use the Navy F-14B"; "F-14B Versus F-15"; "F-15: 'F-14A/B with Phoenix Missile.'"

[30] Osterhout, Berdan, and Gordon, "F-15 Briefing Script," slides 36–37; Lewis, *History of the F-15 Eagle*, 30. The "unjammable" reference pointed to the propensity for missiles to be decoyed by ECM, not necessarily the gun's mechanical functionality and reliability. One official explained in an interview, "The general philosophy on the F-15 is that it's primarily a gun-fighter. Its mission is to get the enemy with the gun, but incidentally while you're getting into position for a gun pass, if it's convenient, fire a missile." Davis, Oral History Interview, May 22, 1973, 9.

offset the additional weight associated with the larger and heavier bullets. The GAU-7 was also expected to have a muzzle velocity of 4,000 feet-per-second and an effective range almost 20 percent greater than that of the M-61, yielding a nearly four-fold increase in the lethality over a 20-mm round. However, the 25-mm system encountered significant difficulties during testing and, rather than delay the F-15 waiting for the GAU-7, TAC finally agreed to temporarily equip its first Eagles with the venerable 20-mm gun. The new gun never materialized. Nonetheless, even with the M-61, an Eagle pilot was still better off in air combat than his predecessors because McDonnell Douglas had decided to cant the gun in the F-15 two-degrees up, essentially providing a head-start for a pilot trying to establish the appropriate lead fire and effectively doubling the "time-in-firing envelope."[31]

As the service began emphasizing the close-range air combat capability of the F-15, questions inevitably arose as to the utility of the Eagle's powerful radar and *medium*-range Sparrow missiles (in comparison to the Navy's *long*-range Phoenix missiles). Early in the design process, Eagle proponents had argued that the radar and Sparrow combination provided "a carefully balanced spectrum of kill potential." However, even Momyer in late 1969 began to question the wisdom of weighing down what was shaping up to be a remarkable fighter plane with a heavy, complex, and costly fire control system. A year later, the Secretary of the Air Force, Robert Seamans Jr., and the new CSAF, General Ryan, both expressed similar concerns.[32]

A number of studies were subsequently initiated to review the necessity of the F-15's radar and radar-guided missiles. In accordance with the earlier emphasis on close-combat maneuvering, the fighter pilots on the Ad-Hoc Committee for F-15 Avionics and Armament elected not to emphasize the Eagle's potential for employing Sparrow missiles from long

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[31] O'Donohue, "Development Concept Paper," 13; Lewis, *History of the F-15 Eagle*, 15, 45, 71–72; Burns, Oral History Interview, March 22, 1973, 12–13; Davis, Oral History Interview, May 22, 1973, 10–13; Osterhout, Berdan, and Gordon, "F-15 Briefing Script," slide 36; Ulsamer, "Accent Is on Flying," 29; "Air Force F-15 Air Superiority Fighter," 2; "F-15 Talking Paper"; *F-15 Eagle*, 8; *USAF F-15 Fighter Summary*, 14; *F-15 Eagle Fact Sheet*, November 1973; *F-15 Eagle Fact Sheet*, February 1973. The up-cant on the Eagle's gun would make it more difficult to use in an air-to-ground role since the aircraft would need to enter a steeper dive angle to attack a ground target.

[32] Lewis, *History of the F-15 Eagle*, 9–11. Others were also starting to question the wisdom of the F-15 and its complex avionics, notably defense analyst Pierre Sprey and Riccioni, who was then working in the Pentagon. The criticisms would eventually contribute to the AIMVAL-ACEVAL tests. See also: Kent, Oral History Interview, 15–17; McIntosh, Oral History Interview, 33–34; Rhodarmer, Oral History Interview, 15, 28–29; Flax, Oral History Interview, 16; Sprey, Oral History Interview; Neufeld, *F-15 Eagle*, 64–65; Coram, *Boyd*, 231–56; Hammond, *Mind of War*, 83–91.

distances approaching a target. Rather, the pilots explained that the value of the Sparrow was that it would make quick work of any enemy aircraft that tried to flee a close-range engagement. The committee members even went a step further and recommended deleting, based on cost, weight, and complexity, the F-15's Electro-Optical Identification and Tracking Set (EOIATS), an updated version of the TISEO system that would soon be deployed on later-model F-4Es to aid in the medium-range air combat environment.[33] Another study conducted during the same time period by Lieutenant Colonel Welch similarly concluded that the primary value of the F-15's radar was not in long-range Sparrow missile employment, but rather in its ability to "provide earlier detection of the opponent and thereby … reduce the probability of entering combat with an initial position disadvantage."[34]

Both reports' conclusions found their way into a 1971 "spread the word" briefing on the F-15. A threesome of fighter pilots, representing "1,155 total hours of combat time" in the F-100 and F-4, travelled throughout the Air Force delivering the nearly hour-long sales-pitch. Extolling the Eagle's capability, they explained that once "the enemy has been found [using the radar], the real name of the game becomes maneuverability and acceleration." Fortunately, they declared, "there is no aircraft in the world that, once in a fight, can disengage from the F-15. There is no maneuver he can perform to get away."[35] A number of other Air Force publications similarly drove home the point that the Eagle and the Eagle pilot were optimized for close-range encounters. For example, a 1975 F-15 "Fact Sheet" explained that "agility in the air at medium and low altitudes is a prime requisite to success" in air combat, and that the "long-range radar detection" capability of the Eagle helps the pilot "in gaining a favorable position for a close in encounter." The document further elaborated on the Eagle's advantages in a dogfight: "The F-15 cockpit is designed to help the

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[33] *F-15 Avionics and Armament Mission Requirements*, v, xv; Lewis, *History of the F-15 Eagle*, 10; Burns, Oral History Interview, March 22, 1973, 11–12; McIntosh, Oral History Interview, 20–22; Rogers, Oral History Interview, 35–36. The F-15's planned EOIATS earned praise during the source selection competition: "[it] significantly exceeds the minimum requirements and will increase the effectiveness of this [aircraft] system." *SSAC Proposal Analysis*, 11. Blesse was not a fan of scrapping EOIATS on the Eagle, complaining that the Air Force's "fuzzy thinkers" were willing to "pay 15 million goddamn dollars for the F-15" but wouldn't cough up "another $170,000 per airplane to put the TISEO in it." Blesse, Corona Ace Oral History Interview, 82.

[34] *Examination of the Utility of the F-15 Attack Radar*, 1, 10–11. A study of the F-15's concept of operations used similar reasoning in justifying the AIM-7F on the Eagle, arguing that the radar-guided missile "will allow the F-15 to extract a penalty from the enemy … who is reluctant to close for maneuvering combat with the superior performing F-15." Holbury, *Concept of Operations for the F-15*, 6.

[35] Osterhout, Berdan, and Gordon, "F-15 Briefing Script," slide 18, 41.

single crewman achieve air superiority through visual air-to-air combat. A Head's-up-Display system provides the pilot with all necessary target and weapons data projected on the cockpit windscreen so that visual acquisition and tracking of the enemy aircraft can be maintained without looking down."[36]

The focus on close-range air combat naturally trickled down to the units when the first F-15s started appearing on Air Force flightlines. The first non-test Eagle was delivered to Luke AFB, Arizona, on November 14, 1974, for use in aircrew training. Sixteen months later in January 1976, the next batch of F-15s officially began arriving at Langley AFB, Virginia, to become part of the 1st TFW.[37] Within a few months, the Eagle pilots at Langley lodged a complaint with TAC: they deemed their regulation-directed "gloss white" helmets a "handicap in the F-15." The pilots explained that their shiny helmets made it too easy for their opponents to see which way they were looking, which could be used to anticipate their next maneuver. Consequently, the Eagle pilots sought permission to "camouflage" their helmets grey. The request was approved two weeks later.[38] Although a minor historical footnote, the incident is an apt indicator of the fledgling Eagle community's focus, and it wasn't on the long-range potential of the F-15's APG-63 radar.

Thus, much like the return of the gun on the F-4 helped stoke the Phantom aircrews' fighter-pilot self-image, so too did the singular air-to-air focus of the F-15, especially the

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[36] *F-15 Eagle Fact Sheet*, 1975, 3–6; Osterhout, Berdan, and Gordon, "F-15 Briefing Script," slide 43.

[37] President Gerald Ford was on-hand to welcome the F-15 into active Air Force service at Luke AFB, proclaiming: "This is the month of the pioneer in America. It is the month of the *Mayflower* and our earliest settlers; and this is the day a new a pioneer—a pioneer of peace—the F-15 fighter. There were 102 passengers on the *Mayflower*; the crossing from England to the new world took more than 2 months, and the end of the journey is freedom. The F-15 can fly across that same Atlantic route today in a matter of hours; the purpose of its journey is still that of the *Mayflower* more than 350 years ago; freedom. That is what really matters—the purpose of a journey, and I am here today to underscore to you and the world that this great aircraft is constructed by the American people in pursuit of peace; our only aim—will all of this aircraft's new maneuverability, speed and power—is the defense of freedom." TAC/OII to AIG/OI, "AFNS Release, 'President Welcomes'"; Sullivan, *History of the 58th Tactical Fighter Training Wing, Oct - Dec 1974*, 10–11. The Air Force had decided to relocate the 1st TFW from MacDill AFB to Langley AFB, also the site of TAC headquarters, before it received its first Eagles. On the 1st TFW move, which was effective July 1, 1975, see: Knight, Oral History Interview, 213; *History of the Ninth Air Force, Jul - Dec 1975*, 1:57–65; *History of the Ninth Air Force, Jan - Dec 1976*, 1:14–19; *History of the 1st Tactical Fighter Wing, Oct - Dec 1975*, 1:9–18; Bloomcamp to 1 TFW/CCH, "History: 1 October - 31 December 1975." On the lineage of the 1st TFW as an air superiority wing, see: *History of the 1st Tactical Fighter Wing, Jul - Sep 1975*, 1:2–3; "1st TFW to Nest Eagles"; "Building an F-15 Wing: Interview with Col Larry D. Welch."

[38] Bloomcamp to 9 AF/DOST, "Helmet Color in the F-15"; Leming to 9 AF/DOST, "Helmet Color in the F-15." Welch remembered that the focus while he was the commander at Langley was on "maneuvering combat.... The reason for the airplane was superiority in maneuvering combat." Welch, interview, October 1, 2013.

emphasis on dogfighting. The Eagle pilots "spread the word" briefing made explicit reference to the fact that finally, they would once again do what fighter pilots historically did. Invoking Richthofen, the briefing script read: "The Red Baron described the air-to-air mission this way—and it is essentially just that—four basic functions: We must go where the enemy is, find him, engage him, and then shoot him down. The F-15 will do all these things better than any fighter in the world."[39]

A Single Seat

There was another feature of the Eagle that rekindled in its pilots the historic glory of fighter aviation—its single seat. Daniel Gillespie identified the F-X's single seat as a "predetermined requirement" of the aircraft, reflective of the "general consensus" among Air Force fighter pilots and their preference for single-seat aircraft.[40] It was also indicative of the F-X's emphasis on close-range air combat, and it helped distinguish the Air Force's F-15 dogfighter from the Navy's two-seat VFX interceptor. However, despite the single seat cockpit quickly becoming a staple of the F-X design, it was unclear at the time if a single pilot would be able to adequately manage all of the tasks demanded of him in modern air combat. The engineers had planned to incorporate advanced avionics and automation into their designs to assist the pilot, but those were many of the same avionics that Momyer and others had begun to question as too complex and costly.

The Air Force's stated preference for a single-seat F-X usually centered on concerns over the additional weight and cost of a two-seat configuration. For example, the F-X Development Concept Paper signed in September 1968 warned that the "addition of a second crewman to F-X could result in a 5,000-6,000-lb. takeoff weight increase … and could add about $0.5 million to flyaway cost." The cited estimates obviously accounted for more than just the second pilot and his associated cockpit equipment, such as a second ejection seat and a set of flight controls. Rather, much of the forecasted increase in weight and cost was attributed to the need for the larger airframe required in a two-seater, which

[39] Osterhout, Berdan, and Gordon, "F-15 Briefing Script," slide 2.

[40] Gillespie, "Mission Emphasis," 225.

would in turn demand more powerful engines and a greater fuel supply "to maintain constant performance" with a single-seat design.[41]

Moreover, with the F-X intended to perform "a majority of [its] missions … in good visibility," Air Force officials saw little need for "a second pilot." This was in marked contrast to the Navy's VFX that, based on its fleet defense mission, would need to be capable of successful employment "in any visibility situation." Hence, it made sense why the Navy was willing to accept "the penalty of carrying" a "second man" who would strictly "concentrate on fire control sensor returns, 'looking through' the adverse effects of weather, clutter, and ECM." With the F-X focused on dogfighting, the Air Force was able to sidestep the second-seat requirement in favor of the "universally recognized" benefits of "smaller aircraft size, weight and cost for a given level of performance" in a "one-man fighter."[42]

Curiously, the winning design proposal from McDonnell Douglas was nonetheless still sized and configured to support an optional two-seat cockpit (figure 5.5). In their first F-15 brochures, McDonnell Douglas boasted of "the easy conversion to the two-place version which adds a second cockpit and all associated controls and displays, … with no change required to major aircraft systems … and with minimal change to cables, wiring and the environmental control system." In fact, a two-seat version would be developed for use in aircrew training, later designated the TF-15. As McDonnell Douglas predicted, the TF-15 model required only

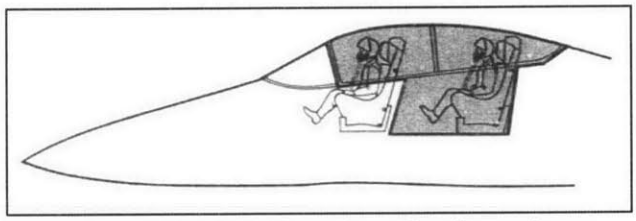

Figure 5.5. F-15 Two-Seat Configuration.
A figure similar to this was included in McDonnell Douglas's F-15 proposal, referenced as *F-15 Eagle*. The shaded area represented the "area of change."
(Source: *USAF F-15*, 22)

[41] O'Donohue, "Development Concept Paper," 7; Glasser, "Research, Development, Test, and Evaluation," 366–67. During Congressional testimony in May 1971, Air Force Lieutenant General Otto Glasser defended the Air Force's decision to make the F-15 a single-seat fighter, explaining, "You add an awful lot of weight and complexity to the aircraft [when you put a second man in it]." The general's assessment drew a wary eye from one Congressional staff member, who interrupted, "A man is not that heavy, General." The general retorted, "A man is 200 pounds, but he takes with him all of the oxygen, another ejection seat, more structure, and armor to take care of him." Additionally, Glasser noted that because the F-15 had only a single air-to-air mission, "it does not have all of the complexities in the avionic equipment that one associates with the multipurpose aircraft that we have become familiar with."

[42] Ibid.

minor modifications and weighed only 800-pounds more than its single-seat counterpart.[43] Nevertheless, few in the Air Force suggested adapting the F-15 into a two-seater for air combat.

There were therefore other rationales driving the single-seat requirement besides simply aircraft cost and weight. The fighter pilots' frustrations with their two-seat Phantoms, several of which were discussed in the preceding chapter, cannot be discounted. It is also important to remember that when the F-X concept was taking shape, the Air Force was still putting two pilots in each of its Phantoms. But even after the shift to professional WSOs in 1969, the issue of crew-coordination and the requirement to verbalize every mode change during a dynamic air-to-air engagement still ranked high on pilots' list of annoyances with the two-seat Phantom. For example, Ritchie maintained long after the war that he "missed a MiG on 13 June [1972] because I had a WSO in the back seat.... If I'd been by myself in that airplane that day, I think I'd have gotten a MiG." The limited cockpit visibility of the two-seat Phantom was also a common complaint. Expressing the opinion of many, Olds noted that "for all-around air superiority, permissive and non-permissive, I prefer a one-man crew.... Without a second crewman, [the pilot] should be able to see much more behind him. The major fault of the F-4 is that it's a neckbreaker."[44]

There was also the powerful, historic allure of the single-seat fighter. If the F-15 was supposed to be the heir to the Sabre, then it only made sense to the pilots that it too would be a single seater. The 1968 Development Concept Paper made explicit reference to the historic imagery in its discussion of the "one vs. two-man crew" considerations for the new F-X, explaining that "visual counter-air missions have classically employed only one man." Moreover, the preference for a single seat was near universal within the ranks. One Air Force survey conducted during the F-X concept formulation phase determined that 96 percent of fighter pilots preferred a single-seat cockpit for visual air combat, and the number

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[43] *F-15 Eagle*, viii, 16; *USAF F-15 Fighter Summary*, 22. Flax, who served as the Air Force's Chief Scientist, took credit for encouraging the service to build a two-seat version of the F-15. Flax, Oral History Interview, 17, 32; Neufeld, *F-15 Eagle*, 28.

[44] Ritchie, Oral History Interview, 29; Olds, "Lessons of Clobber College," 22; Anderegg, interview, October 2, 2013; Wallace, interview. Emphasis in original.

dropped only slightly, to 85 percent, if the mission was going to be conducted at night or in poor weather.[45]

One individual discouraged by the new F-15's configuration was Hendrickson, the WSO-GIB that had helped his Phantom front seater gun down a MiG in October 1972. Like many other WSOs, Hendrickson felt that the second crewmember in the Phantom significantly increased the fighter's capability, especially when "the two people had flown together enough to be able to work together as a crew." After finally finding a way into a fighter, and in the process helping to resolve much of the acrimony that had existed in the Phantom's cockpit by demonstrating what was achievable with a "professional" GIB, the navigator-WSOs suddenly found themselves excluded from the service's newest, premier fighter. Acknowledging that he was "a little prejudiced," Hendrickson lamented, "I think one of the biggest mistakes we could ever make is build an F-15 with only one seat."[46]

It was, in retrospect, a somewhat circuitous logic trail that was used to justify the Eagle's cockpit configuration and its advanced avionics. The F-15 was postured as a dogfighter, which by convention meant that it could only have a single seat. But, in case the F-15 pilot needed to use a Sparrow missile to chase down a fleeing adversary, the Eagle also required a powerful radar, one that historically required a second crewmember dedicated to operating it. Unable to accommodate the second crewmember, the Air Force accepted the increased technological risk associated with developing the more complex, more automated fire control system the Eagle demanded. But then, even after McDonnell Douglas's winning design demonstrated the falsity of the underlying, single-seat assumption, the Air Force elected to continue to link the two design elements. In response to Momyer's and others' concerns about ballooning avionics costs, the 1970 avionics committee had concluded that

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[45] O'Donohue, "Development Concept Paper," 7; Gillespie, "Mission Emphasis," 224; Bowman, "To Fly and Fight," 10; Flax, Oral History Interview, 17, 32; Risner, Oral History Interview, 158. Flax acknowledged the "philosophical arguments" mustered in the debate over a single versus two-seat cockpit configuration. Risner similarly noted that pilots' preference for a single seat cockpit in the F-15: "A typical fighter pilot wants to do everything himself, make his own decisions, and be responsible for his actions. He doesn't want any more crew."

[46] Hendrickson, Oral History Interview, 51; Anderegg, *Sierra Hotel*, 152, 163. Hendrickson continued to work diligently to improve the professionalization of the WSO-GIB in the Phantom; see, for example, Hendrickson, "GIB and ACM."

the F-15's "one-man operability is closely entwined with the look-down capability" only achievable with a "complex and expensive" pulse Doppler (PD) radar.[47]

A PD effectively eliminates ground clutter and false returns from the radar scope. In the Phantom, which used only a pulse radar, the GIB had to manually adjust the radar gain and mentally integrate the movements of a multitude of "fuzzy blips" on his radar scope before he could identify the one, real aircraft target. But in the Eagle, the radar waveform and electronic processing of the PD radar performed the gain control and integration automatically. The avionics committee therefore boasted that the Eagle pilot would enjoy a radar scope "that displays only true targets and not false targets, noise, ground clutter, or large ground point source returns.... This clean scope approach" meant that the pilot theoretically could "scan the radar scope only as frequently as he'd normally scan the rest of his cockpit instruments and still be able to readily recognize a radar target when it appear[ed]."[48] Momyer apparently agreed. When given the opportunity to compare the cluttered radar film from an F-4E with the clean images of the F-15's radar, Momyer "became convinced that TAC pilots had to have this new pulse-doppler radar in the F-15 if the objective of one-man operability was to be achieved."[49]

McDonnell Douglas, as the prime contractor for the F-15, was given authority to select the radar for the aircraft. Westinghouse, which produced the radars for the F-4, and Hughes both submitted viable bids in response to Air Force's August 1968 solicitation. The contract called for a radar capable of detecting "small, high-speed objects" from high altitude "down to 'tree-top' level" at long ranges, as well as the capability of automatically acquiring targets in the short-range environment. After conducting over 100 flights with each radar in an airborne test platform, McDonnell Douglas selected Hughes's PD radar in September

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[47] *F-15 Avionics and Armament Mission Requirements*, vi–v.

[48] Ibid., 125–26; Osterhout, Berdan, and Gordon, "F-15 Briefing Script," slide 10. Hughes Aircraft advertisements noted that APG-63 radar achieved its relatively clutter-free display through a combination of "a low sidelobe antenna, a guard receiver, and frequency rejection of both ground clutter and ground moving targets." *Eyes of the Eagle*, 2. Of course, the radar still occasionally displayed false targets and lost real ones in clutter or the Doppler notch; see assessments in Toliver, *F-15A Follow-On Operational Test Final Report, Annex A*, A–39, A–83. On the advantages of PD radar, see Stimson, *Introduction to Airborne Radar*, 15–30. Welch recalled that the F-15's PD radar was championed by "this little lowly major [who] argued vehemently for a ... look-down, shoot-down pulse Doppler radar. We [fighter pilots] were aghast because that meant a thirty-six-inch flat plate dish in the nose of an F-15. You know what a thirty-six-inch dish in the nose does to acceleration? He won. He was persistent, he was analytic, his logic prevailed, and he won." Welch, interview, July 10, 2012; Welch, interview, October 1, 2013.

[49] Lewis, *History of the F-15 Eagle*, 11.

1970, one month after the Ad Hoc Committee for F-15 Avionics and Armament released its recommendations. The new Eagle radar became known as the AN/APG-63.[50]

Reflecting the Air Force's earlier arguments, Hughes advertised its APG-63 as the "eyes of the Eagle" and "the key to the F-15 one-man operation in all air superiority missions." The APG-63 took full advantage of McDonnell Douglas's original plans for a thirty-six-inch diameter planar radar antenna mounted at the nose of the aircraft, which consequently dictated the massive size of the entire airframe. Besides the large antenna, the system's other black box components dominated the forward section of the fuselage, occupying nearly as much space as the cockpit itself (figure 5.6). For the pilot, Hughes's radar engineers promised a "clutter-free radar display" and detection ranges of "more than 100 miles." The radar also incorporated a three-axis gimbal for the antenna, which would improve the radar's tracking performance during aggressive F-15 maneuvering. For close combat, the radar offered two auto acquisition modes that were designed to be used in conjunction with the pilot's HUD. Harkening back to the original promises of the A-1C(M), Hughes predicted that the "automatic target acquisition and tracking" of the APG-63 would leave "the pilot free to press the attack."[51]

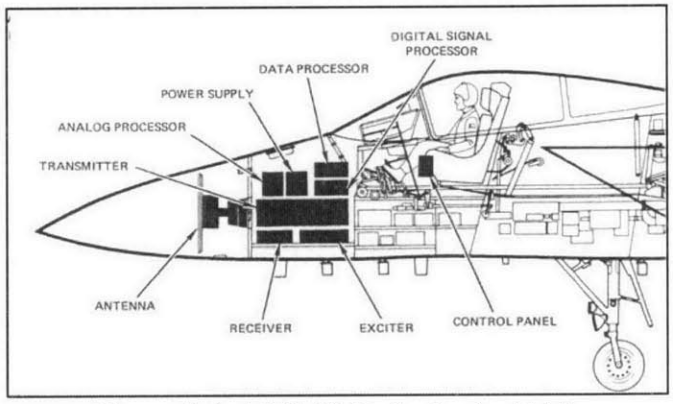

Figure 5.6. APG-63 Radar in the F-15.
(Source: *Eyes of the Eagle*, 5)

That promise, however, assumed that the F-15 pilot could successfully navigate the eight separate controls located on the throttles and the additional five buttons located on the control stick that operated the aircraft's radar and weapons, all of which needed to be actuated in a precise sequence according to the specific engagement parameters. Before in the Phantom, Olds had mentioned that a GIB needed a "bit of dexterity" to properly

[50] O'Donohue, "Development Concept Paper," 3–4; Neufeld, *F-15 Eagle*, 61–62.

[51] *Eyes of the Eagle*, 2. The APG-63 radar also included air-to-ground modes such as "target ranging for automated bomb releases in visual attacks" and "a mapping mode for navigation."

manipulate the F-4's controls. In the Eagle, the pilots would need to become near-virtuoso "piccolo" players.[52]

And Lots of Automation

"It is true the throttles are designed for busy hands," Captain Robert Hoag acknowledged in his Summer 1974 article on the F-15 "Superfighter" in *Fighter Weapons Review*. "However," he continued, "you do not need to be double-jointed or a contortionist to operate any of the controls." Hoag was trying to assuage some of the initial concerns that fighter pilots had expressed when they heard of the multitude of switches and buttons on the Eagle's pair of throttles. He assured his readers, "The F-15 cockpit design and pilot procedures are simple and uncomplicated and require no more than average physical dexterity and common sense." Another pilot emphasizing the functionality of the F-15's cockpit design similarly explained that it was "laid out for the man who is going to use it, not to satisfy an engineer sitting behind a desk." According to Anderegg, however, pilots would quickly discover that "learning how to use all these switches in concert required much practice." Fortunately, flying the airplane did not.[53]

The engineers at McDonnell Douglas understood that if the pilot was expected to single-handedly *employ* the F-15, he probably would need some help *flying* it. They wanted the pilot in their aircraft to be able to "confidently maneuver to the limits of the flight envelope" without having to worry about the aircraft going into a spin with the slightest misapplication of the flight controls as in the earlier Phantom.[54] The solution, they decided, was to use a set of two separate flight control systems in the Eagle. The first was a classic hydromechanical system that relied on "mechanical linkages and hydraulic actuators to position" the aircraft's standard aileron, stabilator (all-movable horizontal tail), and rudder flight control surfaces.[55]

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[52] Olds, Oral History Interview, July 12, 1967, 39–40; Sokol, interview; Anderegg, *Sierra Hotel*, 157. Anderegg noted of the F-15: "Some [pilots] called the constant movement of switches on the stick and throttle 'playing the piccolo.' Others joked that before one could become an Eagle pilot, one had to take piccolo lessons."

[53] Hoag, "Superfighter," 22, 25; Carson, "Flying the F-15," 26; Anderegg, *Sierra Hotel*, 157. Harkening back to Mahurin's description of his Sabre, Welch likened the F-15 to a "Cadillac." Welch, Oral History Interview, 221.

[54] *F-15 Eagle*, 6.

[55] *T.O. 1F-15A-1*, 1–28–30; *F-15 Eagle*, 7; *USAF F-15 Fighter Summary*, 7; Toliver, *F-15A Follow-On Operational Test Final Report, Annex A*, A–5. The hydromechanical system incorporated two additional advancements. The first was a mechanical pitch trim compensator that automatically trimmed the stabilators "without affecting stick position to compensate for … changing speed, operating flaps or speed brake, or [weapons] separation." McDonnell Douglas noted that the auto-trim capability "greatly enhances gunnery tracking capability and helps inhibit pilot induced oscillation." The hydromechanical system also used "mechanical aileron-rudder

The second system was a predecessor to the fly-by-wire systems incorporated in later military and commercial aircraft. The F-15's Control Augmentation System (CAS) used force sensors in the control stick and the rudder actuators to generate electrical signals that were then "superimposed" on the hydromechanical system "to modify the control surface deflections" that resulted from the pilot's physical movement of the control stick and rudder pedals. Although the flight manual did note that "with the CAS on, the aircraft is fully controllable with the loss of any or all mechanical linkages," the electronic flight control system was not included simply for redundancy. Rather, the CAS was an integral component of the Eagle's design. The combination of the electronic force sensors and mechanical pushrods, the engineers at McDonnell Douglas predicted, would provide "an optimum balance of control sensitivity" in their new fighter.[56]

Like Evans's reservations with the F-86E's hydraulically boosted flight control system decades earlier, several F-15 pilots expressed their concerns about relinquishing control of their aircraft to an electronic force sensor located in the control stick. They wondered, "What happens when some berserk electron decides to go on a rampage?" Dismissing the fears, Hoag explained that there were safety features built-in to the two-channel, three-axis CAS to guard against such random behavior, thereby yielding an "extremely reliable" system. While acknowledging that the CAS did sound like "black magic" or "something out of Star Trek," Hoag considered the smooth flying results indisputable. "CAS-ON is the ultimate in aircraft power steering," he wrote. "Simply put, the nose of the aircraft goes where the pilot puts the stick, with the CAS telling the flight controls how much to deflect and when."[57]

Electronic CAS was only one of many features intended to simplify the task of *flying* the Eagle. The automatic positioning of the engine inlets was another. Collectively, this

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interconnect" which adjusted the commanded rudder deflection based on "longitudinal stick position. With the control stick aft of neutral, lateral stick motion causes rudder deflection in the same direction as stick motion. With the control stick forward of neutral, lateral stick motion causes rudder deflection in the opposite direction of the stick motion."

[56] *T.O. 1F-15A-1*, 1–30–31; *F-15 Eagle*, 6–7; Toliver, *F-15A Follow-On Operational Test Final Report, Annex A*, A–5. CAS did not control the ailerons; any roll commands generated by the CAS were achieved through differential displacement of the stabilators. CAS also ensured that "a given stick displacement produce[d] a corresponding constant load factor [or 'g'-force], regardless of altitude or speed," thereby eliminating the Mach tuck phenomenon common in earlier supersonic fighters.

[57] Hoag, "Superfighter," 22–23; Welch, interview, October 1, 2013; Sokol, interview; Wallace, interview; Anderegg, interview, October 2, 2013. Welch recalled of the F-15, it was "almost impossible to get into trouble flying the airplane … [it] was so honest."

automation freed the F-15 pilot to devote more of his attention to *employing* the F-15's fire control system. As noted above, there was considerable emphasis placed on optimizing the radar and weaponry for "one-man operation," and the resulting system was frequently described "as simple as 1-2-3. 1-Look; 2-Select; 3-Fire."[58] While not discounting the remarkable improvements in the APG-63 PD radar and its ability to provide a clutter-free scope, in actuality, F-15 long-range radar and weapons employment remained essentially unchanged from that of the Phantom. The pilot still had to set-up his radar, notice a target that appeared on the radar scope, maneuver the radar's acq symbol over that target, lock it, and then assess the optimum weapons employment. Although the pilot in the F-15 benefited immensely from more intuitive displays, an improved cockpit layout, and better automation and mechanization in the fire control system, it was still a somewhat cumbersome, heads-down procedure that required the pilot to focus significant attention on the radar scope.

The F-15 in air-to-air, long-range search mode used a B-scope similar to that in the Phantom, which was displayed on the Eagle's four-inch-square vertical situation display (VSD) located in the top left portion of the instrument panel (figure 5.7). However, rather than viewing raw radar returns as in the Phantom, the Eagle pilot instead saw a digitally processed representation of the radar. Consequently, there were no "fuzzy blips," only distinct, synthetically generated target "bricks." Furthermore, only those radar returns that exceeded a variable signal-to-noise ratio controlled by the radar's automatic gain control were displayed. "Nothing but moving targets," the F-15 "spread the word" briefing noted, "no clutter or anything else to confuse

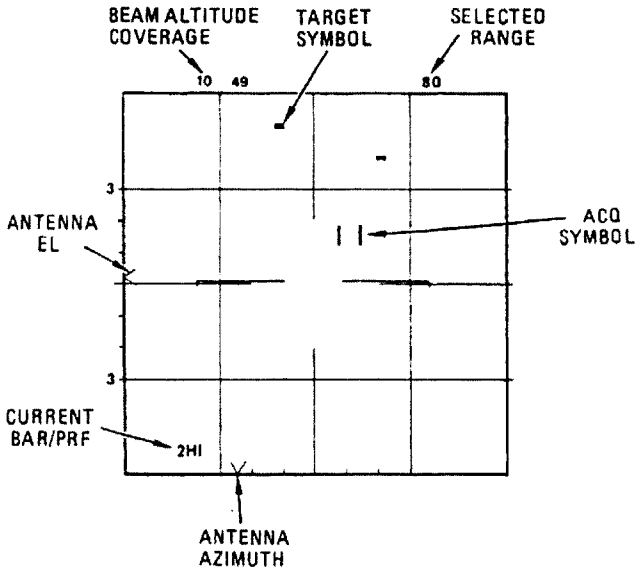

Figure 5.7. F-15 Radar VSD in Search.
The beam altitude coverage displayed at the top of the radar display was calculated according to the antenna elevation angle and the range of the acq symbol. Hence, in this figure, at fifty miles (based on the acq symbol position on the 80-mile scope), the pilot is searching from 10,000 feet to 49,000 feet in altitude. (Source: *T.O. 1F-15A-34-1-1*, 1-54)

[58] *F-15 Eagle*, 12; *USAF F-15 Fighter Summary*, 16.

the display." Some rebuffed the digital processing, complaining that the "highly automated" and "artificially generated" binary radar targets—"either present or not present" on the display—made it more difficult for the pilot to "determine signal strength" and assess the operation and performance of his radar. But Sokol, like most others, appreciated the clarity; comparing the F-15's radar scope to that in the Phantom, he said it was "like the sun just came out."[59]

The radar's automatic processing also obviated the requirement for a manual gain control on the F-15's radar set control panel, which was located on the outboard side of the aircraft throttles (figure 5.8). All told, the F-15's panel had 35 percent fewer knobs and switches than that used in the Phantom (figure 4.17). Moreover, when the Eagle's radar mode control was set to its normal AUTO position, the majority of the radar controls and settings could be adjusted via specific weapons selections using the pilot's HOTAS. Hence, the radar control panel in the Eagle was designed primarily to be set-up on the ground and then rarely touched in the air, a marked change from the F-4 experience.[60]

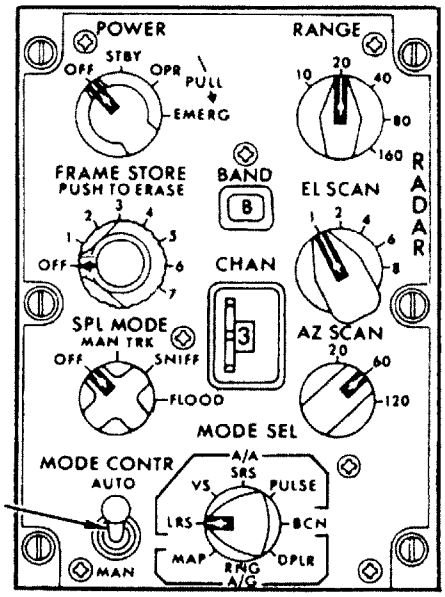

Figure 5.8. F-15 Radar Set Control.
(Source: *T.O. 1F-15A-34-1-1*, 1-44)

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[59] Osterhout, Berdan, and Gordon, "F-15 Briefing Script," slide 13; Sokol, interview; Sullivan, *History of the 58th Tactical Fighter Training Wing, Jan - Mar 1975*, 75. The radar also had the option of presenting targets in a "velocity versus azimuth display," which "provided the capability for detecting high closing rate targets at ranges greater than [long range search] mode." The "VS" or velocity search" mode was used when facing very fast aircraft like the MiG-25 Foxbat; see Toliver, *F-15A Follow-On Operational Test Final Report, Annex A*, A–12, A–17; *T.O. 1F-15A-34-1-1*, 1–52, 1–69.

[60] Hoag, "Superfighter," 22; Anderegg, *Sierra Hotel*, 154; Toliver, *F-15A Follow-On Operational Test Final Report, Annex A*, A–11–12, A–18, A–32–34; Flood and Rodero, *F-15 Initial Operational Test and Evaluation—Air-to-Air*, A3–4, A–7, A–III–2; *T.O. 1F-15A-34-1-1*, 1–42–44, 1–52. With the radar mode control in AUTO, "whenever the pilot selected a new weapon, … the radar operating mode, display range scale, and the az[imuth]- and el[evation]- scan were initialized to the parameters programmed in the CC. For example, the selection of MRM automatically commanded the 80-[mile] range scope, 120-degree azimuth scan, 2-bar elevation coverage, and long-range search mode. The pilot could override any of the initialized conditions … [using] the radar control panel." During the initial F-15 testing, the CC was programmed to initialize a 4-bar, 120-degree azimuth, 20-mile range scope when SRM was selected, and a 10-mile scope range and the supersearch auto acquisition mode when GUN was selected with the weapon select switch.

Normally, the F-15 pilot selected a multiple-bar elevation scan that allowed him to search a larger volume of airspace. To assist with target detection, the radar automatically interleaved each horizontal sweep of the antenna with alternating high- and medium-PRF (pulse repetition frequency) waveforms: high-PRF was better at detecting and tracking targets approaching the F-15; conversely, medium-PRF was better for low-altitude and/or receding targets. So that the pilots didn't have to mentally calculate the radar's altitude coverage when the radar was in search, the CC displayed that information, based on the range of the acq symbol, in the upper left hand corner of the VSD. Additionally, unlike the Phantom, there was no distracting vertical line sweeping across the display in azimuth, just a carat at the bottom of the scope, and the Eagle's antenna elevation carat, located on the left side of the VSD, was actually a reliable indicator of the antenna position.[61]

Once the pilot noticed that a brick had appeared on the VSD, he needed to move the acq symbol over the target to command a lock-on. For that, he used the target designator control (TDC) located on the right throttle (figure 5.9). Although it could be overwhelming at first, navigating the maze of switches and controls on the two throttles was simplified by the different finger positions and tactile feel of the distinct buttons. The TDC, for example, was a slightly dimpled disc approximately the size of a penny that normally rested under the pilot's middle finger. The pilot used the TDC as "an isometric positioning device" to slew the acq symbol across the VSD in azimuth and range. Hoag claimed that the TDC, the "doofer that moves the acquisition symbols around," was so precise that "with a few seconds practice, you can write your name on the scope using this switch." Others, however, found the switch a little too sensitive, especially when trying to command a lock. Once the acq symbol was slewed over the target brick, the pilot needed to depress the TDC to initiate the lock-on process. Anything other than a straight depression, however, would cause the acquisition symbols to slide away from the target, disrupting the lock-on. Pilots soon learned that it took a fine touch to manipulate the TDC and smoothly command a lock. But, with each target brick synthetically generated by the radar, at least there was no longer a need to

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[61] *Eyes of the Eagle*, 2–4; Toliver, *F-15A Follow-On Operational Test Final Report, Annex A*, A–11–12; Flood and Rodero, *F-15 Initial Operational Test and Evaluation—Air-to-Air*, A–26, A–42, A–III–2–14; *T.O. 1F-15A-34-1-1*, 1–25–33, 1–52–54, 1–66. Hughes claimed that the APG-63 was the "only production radar to employ both high and medium PRF." The altitude coverage cues earned praise from the F-15 test pilots, who noted that the "F-15 allowed precise elevation coverage without excess pilot work load." On the advantages of the different PRFs, see Stimson, *Introduction to Airborne Radar*, 325–34.

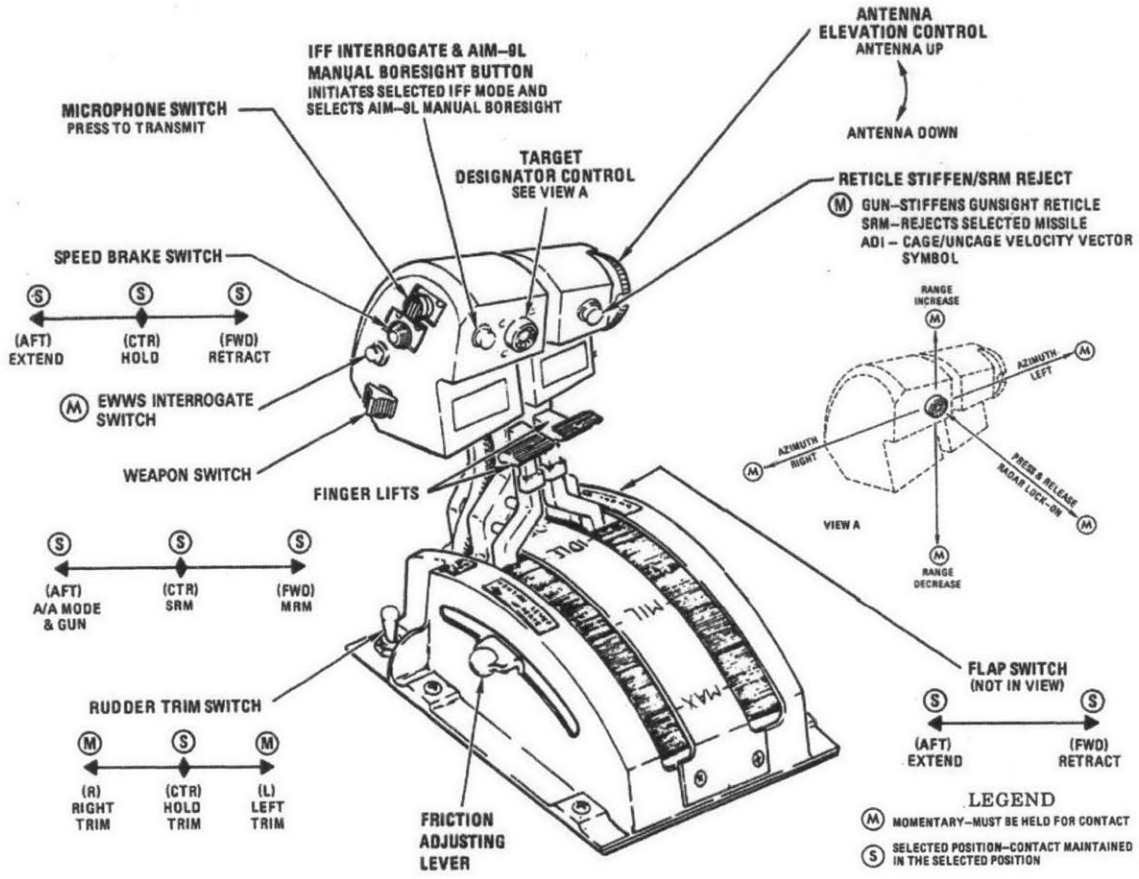

Figure 5.9. F-15 Throttle Quadrant Controls.
(Source: Adapted from *T.O. 1F-15A-1*, 1-5)

first adjust the radar elevation coverage to achieve maximum target brightness, as in the earlier radars; if it was on the Eagle's VSD, it could usually be locked, immediately.[62]

Once the radar was in track, the pilot benefited from a wealth of target information that in the Phantom was only available through verbal coordination with the GIB (figure 5.10). Sokol explained that just having the target's altitude readily displayed was a revelation.

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[62] Hoag, "Superfighter," 25; Osterhout, Berdan, and Gordon, "F-15 Briefing Script," slide 14; Anderegg, *Sierra Hotel*, 156; Toliver, *F-15A Follow-On Operational Test Final Report, Annex A*, A–18–19; Flood and Rodero, *F-15 Initial Operational Test and Evaluation—Air-to-Air*, A–24; *T.O. 1F-15A-34-1-1*, 1–45, 1–56, 1–69. Anderegg declared of the Eagle's APG-63, "No Air Force pilot had ever flown with a radar so capable and so easy to use." Regarding the positioning of the switches on the throttles, the early test pilots complained that the "low position" of the weapons select switch "required the pilot to abandon radar antenna elevation control.... This hand movement resulted in inadvertent displacement of the antenna elevation control." When the pilot commanded lock-on with the TDC, the radar would correlate the position of the acq symbol with the synthetically generated target symbol and the stored radar return and then command the radar antenna to the "elevation, bar, azimuth position, and PRF on which the target was detected." The radar would then initiate a "rapid, 2-bar elevation and ±3 degrees azimuth acquisition raster" around the target's last detected position. After the radar received two subsequent returns, it would enter track.

The target's airspeed, G-loading, and aspect angle (the relative angular position of the F-15 to the target) were also now all plainly displayed across the top of the VSD. As before, an AIM dot and an ASE circle, target Vc, and missile launch estimations (Rmax1, Rmax2, and Rmin) were provided to help the pilot navigate to an acceptable weapons launch position. In the past, however, the GIB would have been available to compute the optimum intercept approach and monitor it while the pilot concentrated his attention outside the cockpit, visually scanning for the target. Now, the Eagle pilot now had to do everything himself.[63]

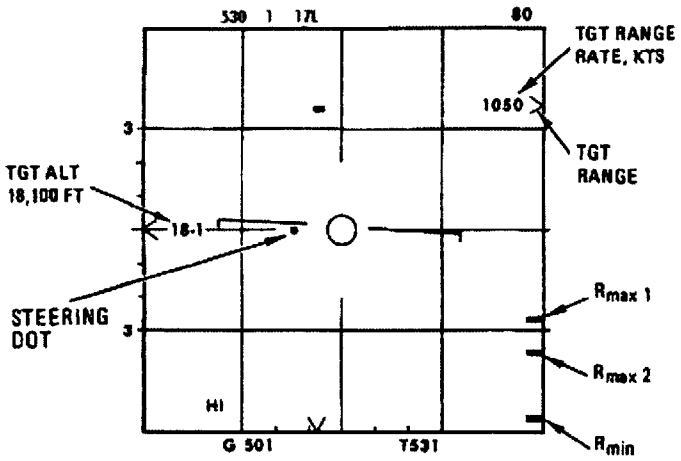

Figure 5.10. F-15 Radar VSD in Track.
The target true airspeed, G-loading, and aspect angle were displayed in the top left portion of the VSD. The F-15's own ground speed and true airspeed were displayed along the bottom of the display. (Source: Adapted from *T.O. 1F-15A-34-1-1*, 1-72)

To aid him, the F-15 included a HUD. Although the hardware appeared similar to that used for the optical sights in the F-86 and F-4, the HUD in the F-15 was much more than just a gunsight.[64] In its normal configuration, the HUD displayed the F-15's current airspeed, heading, altitude, and attitude (figure 5.11, left side). It also included a visual indication of the current weapons selected, such as the MRM (medium range missile) reference circle, and a count of the remaining missiles, for example the M 4 under the airspeed scale which indicated four AIM-7 MRMs aboard. When the radar was locked to a target, the HUD also displayed information from the VSD, such as missile employment cues and the target range and Vc. Some pilots, including Welch, reported being so overwhelmed

[63] Sokol, interview; Anderegg, *Sierra Hotel*, 154; Toliver, *F-15A Follow-On Operational Test Final Report, Annex A*, A–11–12; Flood and Rodero, *F-15 Initial Operational Test and Evaluation—Air-to-Air*, A–30–31, A–III–2–14; *T.O. 1F-15A-34-1-1*, 1–25–33, 1–76–77. "Rmax1 was the computed maximum aerodynamic range of the AIM-7F for a nonmaneuvering $2m^2$ target. Rmax2 was computed for a target performing evasive maneuvers during the terminal phase of the missile flight. A missile launched at Rmax2 had a good probability of success.... Rmin represented the minimum range required for missile guidance and arming." On the basic procedures for conducting a radar intercept in the F-15, see *1 TFW Aerial Attack Manual, Vol. 1*, 9–42.

[64] Anderegg, *Sierra Hotel*, 154. The A-7 was the first Air Force fighter equipped with a HUD, although its performance paled in comparison to the HUD on the F-15.

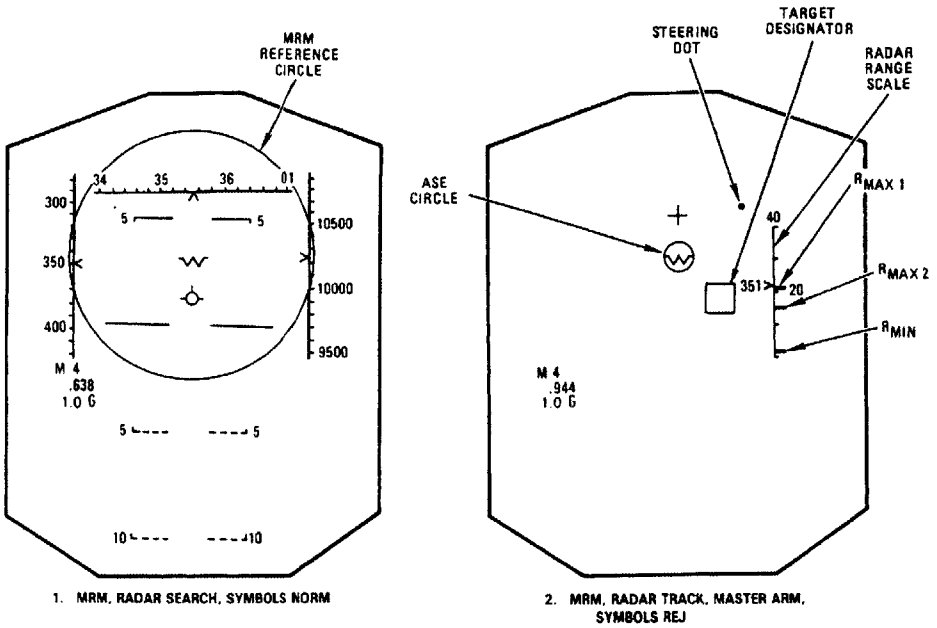

Figure 5.11. F-15 HUD in MRM Mode (Radar Search and Track).

In the HUD image on the left, the aircraft is at 1-G, pointed about two-degrees above the horizon, heading 355°, flying at 350 knots or .638 Mach, at an altitude of 10,250 feet. The pilot has MRM selected on the weapons select switch and has four MRMs (AIM-7 Sparrows) aboard. In the HUD image on the right, the pilot has selected symbols reject, which removed the airspeed, heading, altitude, and pitch attitude scales. The pilot has a radar lock on a target located along the azimuth and elevation of the TD box. According to the carat position on the radar range scale, the target is about twenty-miles away, closing at 351 knots. The F-15 is on the edge of Rmax1 for this target. (Source: Toliver, *F-15A Follow-On Operational Test Final Report*, A-13)

by the information now available directly in front of them that they preferred turning off the HUD's heading, altitude, airspeed, and attitude "scales," (figure 5.11, right side).[65] However, not *all* of the target's information could be displayed on the HUD, and hence, the pilot still needed to periodically scan the VSD during the course of the intercept.

One of the pilots' favorite features of the HUD was its target designator box, which visually highlighted the expected position of the target based on the radar's azimuth and elevation tracking angles. The TD box helped alleviate some of the pilot's anxiety as he struggled to see his target as it neared. Anderegg described the benefits of the TD box: "All the pilot had to do was point [his aircraft] in the general direction of the target, look through the TD box, and there was the adversary! … One pilot called the TD box the greatest thing

[65] Ibid.; Welch, interview, October 1, 2013; Wallace, interview; Sokol, interview; Toliver, *F-15A Follow-On Operational Test Final Report, Annex A*, A–21–24; Flood and Rodero, *F-15 Initial Operational Test and Evaluation—Air-to-Air*, A–89, A–II–1–11; *T.O. 1F-15A-34-1-1*, 1–15–24.

since sliced bread." Hoag likened the nondescript square box in the HUD to "a poor man's TISEO."[66]

All of the information displayed on the HUD and VSD was computed and controlled by a 48½-pound, "amazingly sophisticated" and "very intelligent central computer." The 16k, 34-bit, 340,000-instructions-per-second computer also calculated the aircraft's missile launch zones, intercept steering, and gunnery solutions. As Hoag described it, "this small, light-weight, high-capacity computer … makes the F-15's one-man operation a reality." The GIB in the Phantom had effectively been replaced by the CC in the Eagle. The pilot no longer needed to verbalize his mode changes; instead, he simply repositioned the weapons select switch at the bottom of his right throttle from MRM to SRM (short range missile) or GUN. The CC automatically reconfigured the radar for the new mode (assuming that the radar was set to AUTO) and commanded the ACS to prepare the appropriate weapon. Just to assuage any concerns about a potential loss of cockpit authority to yet another electronic black box, Hoag affirmed that "the pilot still owns the GO – NO-GO responsibility." The CC could tell the pilot when to shoot—it would display a small triangular "shoot cue" under the TD box in the HUD—but the pilot always had to press the pickle button for a missile to launch. Left unsaid was that while the pilot retained ultimate control, a failure of the electronic CC would severely cripple the F-15's offensive employment capability.[67]

Automation and improved data processing and displays had therefore simplified critical elements of the long-range intercept. Welch described the transition: "Suddenly, your job was to integrate real information; not to pick a bit of information out of a lot of non-information."[68] However, the procedures for working the radar and obtaining a long-range radar lock remained comparable to that of the earlier Phantom. Employing the radar-guided Sparrow was also roughly equivalent. Assuming the pilot had obtained a radar lock and had

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[66] Hoag, "Superfighter," 27; Anderegg, *Sierra Hotel*, 154; Sokol, interview. Hoag continued, "Knowing where to look is half the battle; early indications are that visual indications will improve at least 20% using this line of sight designator."

[67] Hoag, "Superfighter," 26; Flood and Rodero, *F-15 Initial Operational Test and Evaluation—Air-to-Air*, A–2; *T.O. 1F-15A-1*, 1–76; *T.O. 1F-15A-34-1-1*, 3–7; Anderegg, *Sierra Hotel*, 154–55.

[68] Welch, interview, October 1, 2013; Flood and Rodero, *F-15 Initial Operational Test and Evaluation—Air-to-Air*, A–26. The initial test pilots agreed, remarking that "pilot workload in the [long range intercept] mission was low due to the accessibility, operability, and ease of interpretation and performance of the F-15 [fire control system]."

MRM selected, he could fire a missile by depressing the weapon release or "pickle" button located on the top of the control stick (figure 5.12). As in the Phantom, the pilot then needed to maintain the radar lock throughout the Sparrow's entire time of flight, but to aid him, the HUD included a countdown of the missile's estimated remaining flight time. When

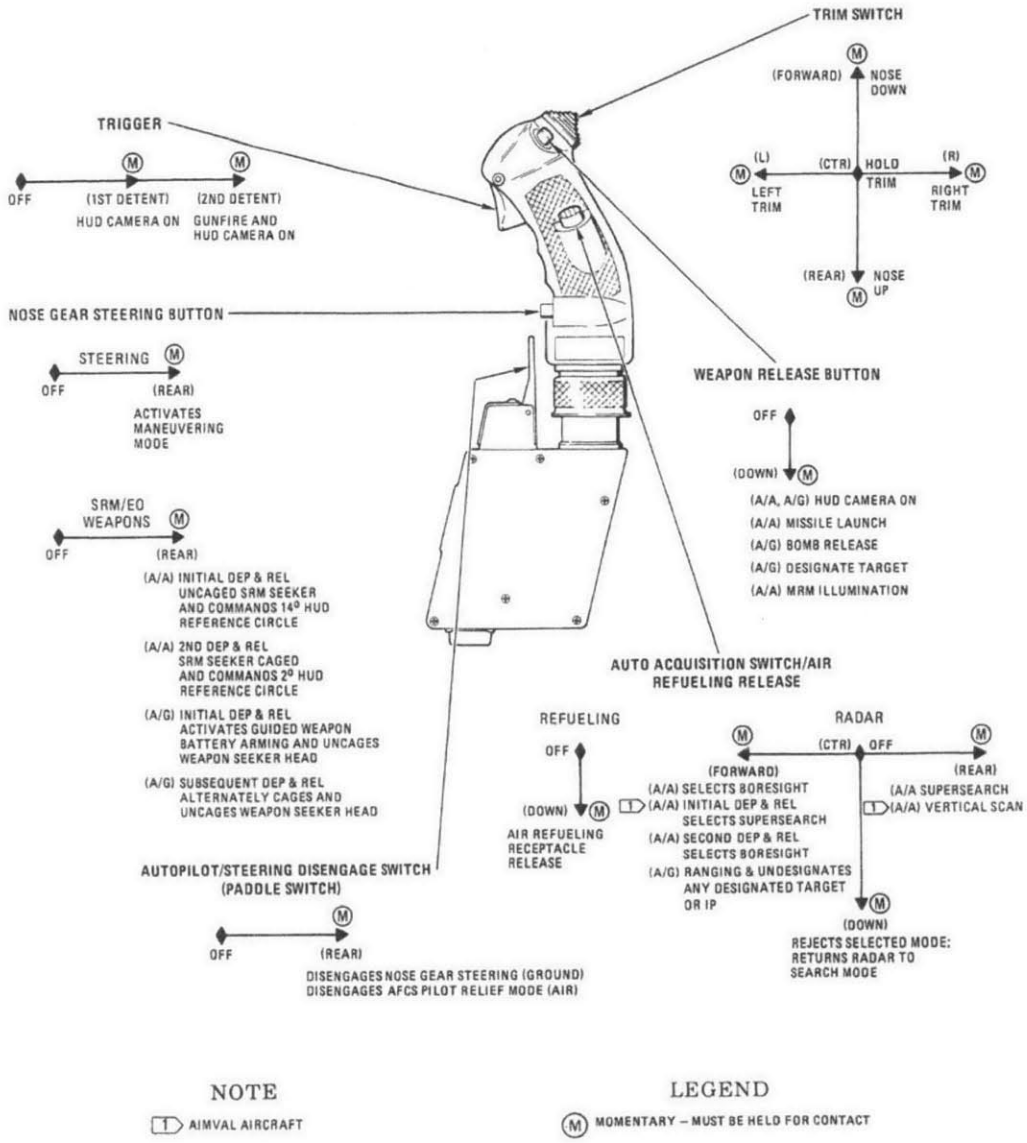

Figure 5.12. F-15 Control Stick.

Entries preceded by (A/A) were functions available in air-to-air mode; entries preceded by (A/G) were functions available in air-to-ground mode. The functions identified with an arrowed-1 were added specially for the AIMVAL tests. The large box at the base of the control stick housed the force sensors used by the CAS flight control system. (Source: *T.O. 1F-15A-1*, 1-27)

he needed to break lock and return the radar to search, the pilot depressed the auto acquisition switch located on the control stick.[69]

The other functions of the auto acquisition switch, besides releasing the air refueling receptacle, were designed for use in the short-range environment. It was in these close-combat situations that the Eagle's fire control switchology and automation allowed for "head out of the cockpit" employment.[70] It's also when the pilot's practice at "playing the piccolo" became readily apparent. The F-15 fighter pilot had to learn to anticipate not just the enemy's actions and how he would maneuver to follow them, but also which weapon (selected on the throttle) and which auto acquisition radar mode (selected on the control stick) he should use based on the specific maneuver to maximize his offensive capability. Just as the pilot in the past did not have time to consciously think through a barrel roll lag maneuver while following an adversary, the Eagle pilot now had a similar requirement when using his HOTAS. In short, the intuition that had previously guided fighter pilots' maneuvers during a dogfight now had to be extended to the switch actuations localized within his cockpit.

For example, if the Eagle pilot visually detected an adversary and he did not already have a radar lock, he needed to instantly decide which auto acquisition mode was most appropriate for the situation. He had two options. One was boresight, a mode similar to that originally intended for use in the Phantom, except that in the Eagle it actually worked. The pilot initiated boresight by thumbing forward on the auto acquisition switch. The radar would then begin staring directly in line with the aircraft, searching in range from 500 feet out to ten miles. A four-degree reference circle was displayed in the HUD to aid the pilot in pointing the aircraft, and thereby the radar, at the target (for reference, the MRM reference circle in the left image of figure 5.11 is twelve degrees). The radar would lock the closest target in range and then automatically transition to full system track, indicated by the appearance of the standard radar track information in the HUD. If there were multiple targets in range and the radar locked the wrong one, the pilot could depress the auto acquisition switch to break the radar lock, adjust the aircraft position so that only the desired

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[69] Hoag, "Superfighter," 28; *T.O. 1F-15A-34-1-1*, 1–75–79. Unlike the Phantom, the Eagle did not have a special CW illuminator to help guide the Sparrow missile; instead the Eagle used the APG-63's high PRF waveform. This meant that the before launching a Sparrow, the F-15 CC had to ensure that the radar was tracking the target using high PRF, and if not, the CC needed to command the radar to make the switch.

[70] *USAF F-15 Fighter Summary*, 4.

target was in the four-degree boresight circle, and then thumb forward again to reinitiate boresight. Or, while he still had a lock, he could simply thumb forward again on the auto acquisition switch to reject the first radar target and skip to the next closest target in range.[71]

If the pilot did not want to use the boresight radar mode, he could thumb aft on the auto acquisition switch and initiate supersearch. In supersearch, the radar searched an area roughly in line with the HUD field of view, twenty degrees by twenty degrees, from 500 feet out to ten miles, the same range of boresight. The advantage of supersearch was that the pilot didn't need to precisely point at the target to obtain a radar lock, but it also was therefore less discriminatory and not particularly useful when approaching a swirling dogfight involving multiple aircraft. Additionally, because the supersearch search area was larger than that of boresight, it generally took longer to detect a target and resolve a radar lock. When supersearch was active, a twenty-degree circle was displayed in the HUD to help cue the pilot. As in boresight, the radar would lock the closest target in range, and thumbing aft on the auto acquisition switch with a lock would cause the radar to break lock and skip to next closest target in range.[72]

There was at least one important gotcha, though. If the pilot entered supersearch from normal radar search, depressing the auto acquisition switch to either reject the lock or discontinue supersearch would return the radar to normal search. However, if the pilot had thumbed forward to select boresight and then selected supersearch by thumbing aft, perhaps because the target aircraft was exiting the four-degree boresight circle, and then the pilot depressed the auto acquisition switch to reject the lock, he would return not to normal search but instead to boresight. Furthermore, although much faster than in the Phantom, the Eagle's radar could still take more than two seconds to resolve a lock and for the CC to then change the displays on the HUD and VSD.[73] A pilot could therefore easily get out-of-sync

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[71] Hoag, "Superfighter," 26; Osterhout, Berdan, and Gordon, "F-15 Briefing Script," slide 16; Toliver, *F-15A Follow-On Operational Test Final Report, Annex A*, A–18; Flood and Rodero, *F-15 Initial Operational Test and Evaluation—Air-to-Air*, A–7, A–78; *T.O. 1F-15A-34-1-1*, 1–57, 1–70.

[72] Osterhout, Berdan, and Gordon, "F-15 Briefing Script," slide 15; Toliver, *F-15A Follow-On Operational Test Final Report, Annex A*, A–18; Flood and Rodero, *F-15 Initial Operational Test and Evaluation—Air-to-Air*, A–7, A–78, A–91; *T.O. 1F-15A-34-1-1*, 1–57, 1–70. The pilots in the 1st TFW observed that "supersearch is degraded during high 'G' maneuvering" and therefore recommended using boresight in those situations. *1 TFW Aerial Attack Manual, Vol. 1*, 66.

[73] Toliver, *F-15A Follow-On Operational Test Final Report, Annex A*, A–18; Osterhout, Berdan, and Gordon, "F-15 Briefing Script," slide 15; Hoag, "Superfighter," 26. More simply stated, supersearch would return to the "operating mode from which [it] was entered."

with his switchology as he raced to get a radar lock in a dynamic and high-stress, short-range combat environment. Proficiency and purposeful, deliberate actuations of the various switches and buttons were vital in avoiding getting entangled in the maze of HOTAS functionality.

As the pilot was working to get a radar lock, he also needed to anticipate which weapon he would need to employ, which he selected using the three-position weapon select switch located on the right throttle.[74] The pilot had to be careful, though, because if he didn't already have a radar lock, adjusting the weapons select switch (assuming the radar mode was set to AUTO) could also change the radar configuration and alter the VSD display. If he had a lock, then adjusting the weapons select switch would have no effect on radar settings, but it would still alter the symbology in the HUD. For example, if the pilot switched from MRM to SRM, the twelve-degree MRM reference circle was replaced with a two-degree AIM-9 Sidewinder seeker circle.

To then employ the AIM-9, which had the advantage of not tying up the Eagle's radar like a Sparrow missile during its time-of-flight, the pilot first needed to position the two-degree seeker circle in the HUD over the target before commanding the AIM-9's seeker to uncage and begin tracking the target's heat source. The pilot accomplished the second step by depressing the nose gear steering button at the bottom of the control stick. The pilot then listened for the trademark Sidewinder "growl" that indicated that the missile seeker had found and was tracking a target. If he suspected that his Sidewinder missile was malfunctioning, the pilot could depress the SRM reject button on the left throttle to switch to a different AIM-9. If the missile seeker failed to find the target, the pilot needed to recage the missile by re-actuating the nose gear steering button before trying again. Once he had verified a good missile "tone" and that he was in range and in proper firing parameters, indicated by the CC displaying a Sidewinder missile shoot cue in the HUD, the pilot could launch the missile using the weapons release button on top of the control stick.[75]

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[74] The only weapon that actually required a radar lock for employment was the Sparrow. However, a lock provided valuable target ranging when employing a Sidewinder or the gun, and allowed the CC to compute and display weapons employment information in the HUD to aid the pilot.

[75] Toliver, *F-15A Follow-On Operational Test Final Report, Annex A*, A–12; *T.O. 1F-15A-34-1-1*, 1–80–88. The HUD and VSD provided similar CC-computed weapons employment displays as with the Sparrow, except that only a single Rmax was displayed with the Sidewinder.

Gun functionality was present regardless of the position of the weapon select switch, a reflection of the importance the pilots attached to always having a weapon immediately available. Hence, anytime the pilot squeezed the trigger (assuming that the aircraft was armed), the 20-mm gun would fire. Selecting GUN with the weapon select switch merely commanded the CC to begin calculating the gunnery solution and display the gunsight in the HUD (figure 5.13). If the radar was locked to a target, the CC used that range in its computations. If there wasn't a radar lock, the CC calculated the gun solution using a fixed target range of 2,250 feet; the pilot could adjust that range input to 1,000 feet if he depressed the reticle stiffen button on the left throttle (the same button used to reject a bad Sidewinder when the weapons select switch was in SRM). In practice, the Eagle's gunsight was remarkably similar to the A-1C(M) used decades earlier: the gun reticle moved on the HUD according to the amount of lead required, and the pilot simply needed to maneuver his aircraft to place the target under the reticle before squeezing the trigger.

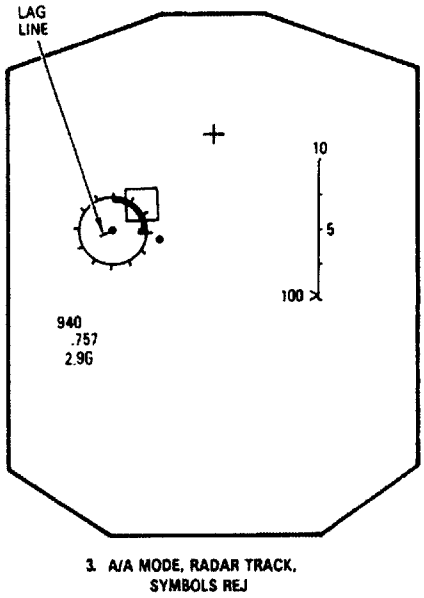

Figure 5.13. F-15 HUD in Gun Mode (Radar Track)
(Source: Toliver, *F-15A Follow-On Operational Test Final Report*, A-16)

There were, however, some improvements to the display that offered additional information to the pilot. For example, if a radar lock was available, the range to the target was indicated using a clock position format on the gun reticle. Hence, the target in figure 5.13 is at approximately 3,000-feet range. The small dot located on the outside of the gun reticle indicated the expected maximum effective range of the bullets based on the altitude and airspeed of the engagement. Also, if the CC was in the process of updating the gun solution, a lag line would appear inside the gun reticle, indicating the direction the reticle was moving as it corrected for the change in the gunnery solution.[76]

Along with its gun and CC-calculated gunsight, the Eagle also included a gun camera, which was mounted inside the cockpit and peered through the HUD. This position allowed

[76] Hoag, "Superfighter," 27; Toliver, *F-15A Follow-On Operational Test Final Report, Annex A*, A–24, A–35; Flood and Rodero, *F-15 Initial Operational Test and Evaluation—Air-to-Air*, A–2–3; *T.O. 1F-15A-34-1-1*, 1–89–96; *T.O. 1F-15A-2-24*, 1–20, 1–36–40. As a backup, the HUD componentry also contained its own LCG.

the pilots to capture not only the effects of their attacks, but also the images of the HUD-displayed weapons parameters during the attack (figure 5.14). Anytime the pilot squeezed the trigger or depressed the pickle button, the camera would automatically start filming, and it would continue recording for an adjustable time duration after the trigger or pickle button had been released. The pilots in the 1st TFW at Langley planned to use the Eagle's enhanced "film documentation" to better track their performance, comparing their "weapons firing attempts vs [the probability of] success." But, issues remained. First, the aircrews had to get their film developed and processed in a timely manner if it was to be of use. Additionally, since not all of the important target information from the VSD was included on the HUD, pilots sometimes found themselves missing a key target parameter needed to judge the weapon's potential success. Finally, the camera system still had no way to record voice or radio transmissions, which provided a crucial context that allowed the pilots to understand what was happening on the film. To help alleviate the last deficiency, the pilots, just as they had once before in the Phantom, began carrying portable cassette tape recorders into the cockpit.[77]

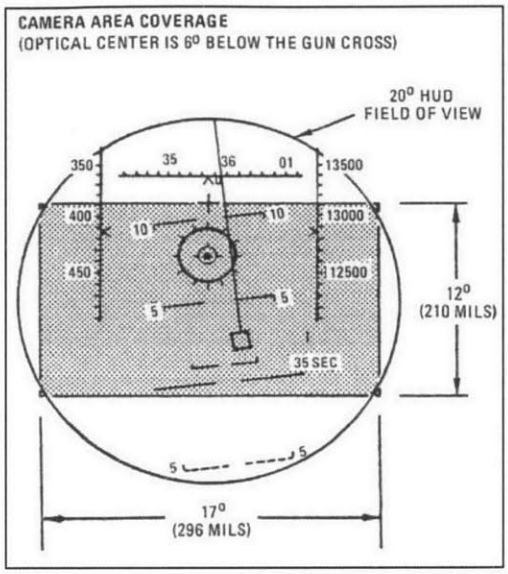

Figure 5.14. F-15 HUD Camera Area Coverage.
The HUD in this figure is configured for air-to-ground. (Source: Toliver, *F-15A Follow-On Operational Test Final Report*, A-31)

One of the Air Force officers responsible for the development of the Eagle remarked in mid-1969 that, because "visual combat maneuvering will be with us for a long time," the F-15's designers were working hard to avoid "burden[ing] the aircraft with any avionics gimmickry which imposes weight penalties and increases costs." But, he also noted,

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[77] Toliver, *F-15A Follow-On Operational Test Final Report, Annex A*, A–30; Flood and Rodero, *F-15 Initial Operational Test and Evaluation—Air-to-Air*, A–118–19; *T.O. 1F-15A-34-1-1*, 4–14; Welch, *Weapons Delivery Image Recording System*; Shepard, *Tactical Weapons Employment Effectiveness*; *History of the 27th Tactical Fighter Squadron, Jan - Mar 1976*, 10; *History of the 27th Tactical Fighter Squadron, Apr - Jun 1976*; Romer and Braeden, "Letter of Agreement"; Sokol, interview; Wallace, interview. The 1st TFW's *Aerial Attack Manual* asked pilots to "attempt to [verbalize and] record the range, angle-off, 'G' loading, and closure rate of the firing aircraft on the tape recorder. This information, coupled with the gun camera film, will give an estimation of kill probability and will be useful in the debriefing." *1 TFW Aerial Attack Manual, Vol. 1*, 6, 9.

"We do want a high degree of automaticity and simplified operation in the cockpit."[78] The Eagle's different short-range radar auto acquisition modes, the HOTAS functionality for selecting them along with the different weapons, the target information that was automatically selected for display in the HUD, and the camera that recorded the HUD information all reflected the careful balance negotiated by the engineers. The pilots certainly appreciated the attention to detail and the improved capability it brought. For example, Anderegg quoted one Phantom pilot's assessment that only when he sat in an F-15 and "saw what we could do in later years, that's when the travesty of Vietnam came home to me." Anderegg himself remarked that "it probably took me a year of flying the [Eagle] before I stopped saying to myself at least once per mission, 'Well, they got this right.' I mean, all the things that were wrong with the F-4, they were all fixed in the F-15.... It was just a joy."[79]

However, few pilots would ever suggest that employing the F-15 was "as simple as 1-2-3," despite what the glossy brochures had once advertised. The Eagle required the fighter pilot to develop a whole new level of air combat intuition so that he could quickly and properly interact with the aircraft's radar and CC through the various switches and buttons that adorned his control stick and throttles. A pilot that was out of practice could quickly find himself accidentally breaking the radar lock while a Sparrow missile was still in flight; or accidentally breaking a just-resolving radar lock by impatiently re-commanding boresight; or accidentally launching a caged Sidewinder missile instead of a Sparrow because the weapon select switch was left in SRM and not MRM. To be effective in the air now required considerable, recurring practice manipulating the controls and processing all of the information available on the displays. Welch suggested that the new skillset reflected the fighter pilot's transition from being a "systems operator" in the Phantom to becoming an "information integrator" in the Eagle.[80] It was likely not the shift fighter pilots had envisioned when they first heard the claims that Eagle was going to be *their* fighter.

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[78] Colonel Robert Titus is quoted in Ulsamer, "F-15: Tomorrow's Champion," 31, 33. Titus was in the office of the Deputy Chief of Staff for Research and Development.

[79] Quoted in Anderegg, *Sierra Hotel*, 157; Anderegg, interview, October 2, 2013; Sokol, interview; Wallace, interview.

[80] Flood and Rodero, *F-15 Initial Operational Test and Evaluation—Air-to-Air*, A–24, A–73; Welch, interview, October 1, 2013. The Eagle's test pilots experienced many of these issues firsthand. One report noted that despite the distinct HUD symbology, the pilots sometimes had a difficult time recognizing what mode they were in or what weapon they had selected. Consequently, they "would frequently" cycle the weapon select

The F-15 was supposed to be the world's premier dogfighter, but it had emerged from the design process a massive aircraft, nearly the size of a tennis court, weighed down by a radar and a suite of avionics so complicated that it took a separate, specialized central computer to help coordinate their activities. Despite the praise that Hoag and others heaped on the F-15, and the justifications mustered supporting the Eagle's advanced avionics for its close-combat mission, some fighter pilots wondered how exactly the F-15, other than its single seat, was reminiscent of the small and simple F-86 Sabre of MiG Alley fame. Boyd was one of them; looking at what the F-15 had become, "he could tell that his dream for the pure fighter aircraft had vanished."[81] Moreover, a group of defense analysts began to address the opportunity costs of building a large, $10 million fighter crammed with expensive and potentially failure-prone equipment. Wouldn't the service and the nation be better off building a smaller, cheaper fighter that had a clearer design connection to history's most successful fighter aircraft? Their question would eventually culminate in the fledgling Eagle's most important trial, not in war over central Europe, but in a pair of tests conducted over the desert north of Las Vegas.

Trial by Test

The joint Air Force-Navy AIMVAL-ACEVAL tests conducted in 1977 constituted the most realistic and comprehensive experimental evaluation of air combat practices and equipment ever attempted. By the end of the year, the pilots collectively had flown approximately 5,900 sorties and the bill for the pair of tests had eclipsed $150 million; more than triple the original price tag.[82] The tests, which promised to "combine real world factors,

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switch "to reaffirm" its position, which had the unfortunate effect of causing "undesirable automatic changes in radar modes and search coverages."

[81] Coram, *Boyd*, 231.

[82] AFSC/CS to ADTC/CC et al., "ACEVAL/AIMVAL Test Plan"; DSAF/OIP to AIG, "ACEVAL/AIMVAL News Release"; CSAF/XO to TAC/CV et. al., "Air Force ACEVAL/AIMVAL Test Directive"; "Point Paper on the ACEVAL Flight Trials"; Tissot and Hildreth, *AIMVAL Final Report, Vol. 1*, III–2; McKenzie and Hildreth, *ACEVAL Final Report, Vol. 1*, III–7; Everson, *ACEVAL Final Report*, 138; Lake, "ACEVAL-AIMVAL Program Review," 5044; Fay, "AIMVAL-ACEVAL Final Report Briefing," 420; Sparks, interview; Sullivan, *History of the 58th Tactical Fighter Training Wing, Jul - Sep 1976*, 24–25. The AIMVAL-ACEVAL Preliminary Test Plan estimated the tests' total costs at $45M. By the time of the official AIMVAL-ACEVAL public news release, cost estimates had risen to $64M. A 1981 review of the tests pegged the final cost figure at $150 million. Curiously, test officials' statements to Congress on AIMVAL-ACEVAL repeatedly claimed a $42 million price tag. The discrepancy may be due to ancillary aircrew training sorties, which were included in the Air Force's internal cost estimates but excluded from the official reports. The test sortie totals also experienced an increase of nearly a third over initial estimates.

statistical probabilities, and computer models in [a] single effort to produce a management-oriented evaluation of relative operational utility," were intended to address the emerging "quality" versus "quantity" debate in military aviation.[83] The "quality" advocates were pushing for extremely capable aircraft like the F-15, knowing that the aircraft's high price tag would preclude procuring significant quantities of them, but contended that the technological superiority of the aircraft would compensate for their numerical deficiency. In contrast, the "quantity" promoters argued that the Air Force should forsake its unhealthy appetite for technological gadgetry like radar-guided air-to-air missiles and instead steer that money toward acquiring greater quantities of simpler, cheaper aircraft like the F-5.[84] Although largely unacknowledged today, the AIMVAL-ACEVAL tests would shape the next twenty years of US military investment in tactical aviation. Whereas the Air Force had earlier in the decade emphasized close-range air combat in the design of its F-15 Eagle, following AIMVAL-ACEVAL the service made an abrupt shift in its procurement strategy, largely abandoning close-range dogfighting weaponry in favor of improved radar-guided missiles such as the AMRAAM (Advanced Medium Range Air-to-Air Missile) and new EID technologies. The fighter pilots too needed to adapt their tactics and procedures to emphasize longer-range air combat. It was, Blesse observed during his visit to Nellis during AIMVAL, a "strange" set of outcomes from a pair of tests originally focused on "short-range [IR-guided] missiles."[85]

Despite the unprecedented level of resources devoted to AIMVAL-ACEVAL, the tests never resolved the "quality" versus "quantity" conundrum. Indeed, one Senate staffer questioned before the tests even began if they would be capable of "really proving the thing [the services] have to prove." After the evaluations kicked off, it became clear that there were too many ambiguities and constraints in the tests and that their resulting data could be too easily manipulated to advocate for either "anti-technology" or "total-technology" positions. Nonetheless, those involved in the tests appreciated their ancillary benefits, especially the attention being directed toward developing a better understanding of air

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[83] *History of the Air Force Test and Evaluation Center, 1 Jan - 31 Dec 1977*, I:271.

[84] On the "quantity" versus "quality" debate, see: Fallows, *National Defense*; Kross, *Military Reform*; Merritt and Sprey, "Quality, Quantity, or Training"; Deming, "Force Structure Decision"; "Fightergram: The Quality-Quantity Controversy"; Anderegg, "Meeting the Threat"; Correll, "Reformers"; Michel, "Revolt of the Majors."

[85] Blesse, "Changing World of Air Combat," 34.

combat. Commenting on the tests' significance, the executive assistant for the test program, Lieutenant Colonel Robert Fay Jr., told one reporter, "Every perceived principle of air combat I came in here with has changed." Sokol, one of the eight F-15 pilots that flew in the tests, later explained that the concentrated, focused experimental analysis of AIMVAL-ACEVAL accelerated development of air combat tactics in the Air Force by at least five years. Welch, who oversaw a portion of the tests while serving on the TAC staff following his command tour at the 1st TFW, captured both the tests' benefits as well as their issues in his appraisal, noting that the Air Force and its fighter pilots learned some "pretty darn good lessons out of a … very badly flawed, politically motivated, Congressionally directed, horribly expensive test program."[86]

In fact, the early experiences of the Eagle pilots assigned to the 1st TFW at Langley AFB in 1976 and 1977 had already begun to reveal, at least anecdotally, many of the same lessons that were later derived from the data-intensive AIMVAL-ACEVAL program. Foremost was the fact that, after having been promised a modern-day Sabre, the Eagle pilots' best chances at victory and survival were attained not in close-combat, but rather when they purposefully avoided the once-iconic dogfight.

Initial Tactics Development

As members of the first operational F-15 wing not focused exclusively on training new aircrews, the pilots in the 1st TFW at Langley AFB played an important role developing the Eagle's early air combat tactics.[87] Their sixty-seven-page *Aerial Attack Manual, Vol. 1*, released the same time the first few F-15s started arriving at the base in January 1976, set the

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[86] Lake, "ACEVAL-AIMVAL Program Review," 5050; Sparks, interview; "No-Win War at Dogbone Lake," 56; Sokol, interview; Welch, interview, July 10, 2012; Cliver, interview; Dvorchak, interview; Amlie, *Non-Statistical Look at AIMVAL/ACEVAL*, 1; Watts, *Six Decades of Guided Munitions*, 50. Later, the commander of the tests' F-15s and F-14s agreed with the staffer's assessment, remarking, "The test objective of quantifying the influence of 'numbers' on engagement outcomes had not only not been achieved, but was 'probably an impossible task.'" There were initially six Air Force F-15 pilots assigned to support the AIMVAL-ACEVAL tests. When the program fell behind schedule, two more pilots were added; one was Sokol, who happened to be at Nellis, assigned as an instructor at the Weapons School and preparing for the inaugural F-15 class.

[87] First to receive the F-15, the 58th Tactical Fighter Training Wing at Luke AFB provided the initial aircraft training for all Eagle pilots; see: Sullivan, *History of the 58th Tactical Fighter Training Wing, Oct - Dec 1974*, 31–34; Sullivan, *History of the 58th Tactical Fighter Training Wing, Apr - Jun 1975*, 35–38; Sullivan, *History of the 58th Tactical Fighter Training Wing, Jul - Sep 1975*, 25–27; Sullivan, *History of the 58th Tactical Fighter Training Wing, Jan - Mar 1976*, 23–25; Sullivan, *History of the 58th Tactical Fighter Training Wing, Apr - Jun 1976*, 40–44; Sullivan, *History of the 58th Tactical Fighter Training Wing, Jul - Sep 1976*, 35–39. The Eagle also continued to undergo testing at Edwards and Luke AFBs; see, for example, Toliver, *F-15A Follow-On Operational Test Final Report, Annex A*.

tone. While the manual's authors acknowledged that the F-15 was "a true fighter pilot's fighter," they also emphasized that "the F-15 is not a magical airplane. It will not automatically maneuver to six o'clock and 'kill.'" Hence, "success in aerial combat" still demanded an aggressive pilot that was "knowledgeable in tactics and procedures." Fortunately, the authors also explained that many of the close-range air-to-air maneuvers and the longer-range intercept geometries remained unchanged from those developed earlier for the Sabre and Phantom; "only the techniques to accomplish them are different."[88] One of their tools to help cultivate proficiency with the new techniques was a novel training scenario that allowed the pilots to rehearse the "necessary switchology and judgment" required in the Eagle. Appropriately named the "ACE (air combat event) maneuver," the training event required the pilot to work the radar and HOTAS to launch a valid (simulated) AIM-7 missile, followed by an AIM-9 missile, while simultaneously maneuvering into a stabilized position for a stable, "tracking" gun shot against a turning target in a minimum amount of time. The pilot's performance during the training event was judged using the HUD film and the portable cockpit voice cassette recorder.[89]

The pilots in the 1st TFW had an opportunity to showcase their new aircraft and their fresh skills when the 64th Aggressor Squadron showed up at Langley in April 1976 to train with them. Welch took special pride in the performance of his Wing's pilots and their aircraft during the ensuing training missions. In the past, when the Aggressor squadrons had visited his old F-4 unit, Welch admitted that the specially trained pilots flying their "goddamn little F-5s" simulating Soviet MiG-21s "would wax our ass"—a fighter pilot colloquialism that referenced the opponent's gunsight being all over their aircraft's tails. Moreover, during the final out-briefs, the Aggressor pilots were always "so magnanimous" it was infuriating. During this trip however, facing off against the new F-15s, the Aggressors had their hands full. "We handed them their ass big time," Welch proudly remembered, and "at the out-brief, you cannot believe how magnanimous we were."[90]

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[88] *1 TFW Aerial Attack Manual, Vol. 1*, i, 1, 67.

[89] Ibid., 54–55.

[90] Welch, interview, July 10, 2012; *History of the Ninth Air Force, Jan - Dec 1976*, 1:172. Differing form Welch's recollection, at the time of the spring 1976 deployment, the 64th Aggressor Squadron was still flying the underpowered, two-seat T-38; their F-5Es would not arrive until later that year. While at Langley, one of the Aggressor's T-38s crashed in the Atlantic during a training mission. See also: "'Aggressors' Organized to Reduce Casualties"; "Eagles Tangle with Aggressors."

Beyond offering a bit of payback for earlier air combat injustices, the training missions against the Aggressors were one of the first opportunities the Langley pilots had to practice employing their Eagles in scenarios where they were out-numbered. The experience yielded an important lesson: even though the performance of the Eagle far exceeded that of the Aggressors' aircraft, tangling with a skilled pilot in a capable, albeit not equal, fighter aircraft was not always advisable. After the training deployment, the Eagle pilots concluded that if they didn't think they could "kill the bogey" in less than thirty seconds, then they were better off exiting the fight to "gain separation, and try[ing] it again."[91]

The new tactics were in some respects similar to the element tactics developed by the Phantom pilots years earlier over Vietnam. There, the Phantom crews needed to extricate themselves from a fight so that they could gain the necessary separation to use their missiles. The F-15, in contrast, had suitable close-range weaponry, but the Eagle pilots learned that they could still get shot by an "unseen bogey" if they focused too closely on gunning down a target. The pilots reluctantly decided therefore to start using their aircraft's superior power and maneuverability to temporarily escape a battle rather than engage in a swirling dogfight. Judiciously deciding when to rely on their long-range missiles and when to close for a close-range gun attack, and having the necessary familiarity with the Eagle's radar and weapons systems to seamlessly transition between the two, quickly became the hallmark of a good Eagle driver. As one summary report of the training missions against the Aggressors noted, an F-15 pilot needed to be "aggressive, calm, knowledgeable, sneaky, inventive, and patient." While they might have preferred the adrenaline rush of a high-G, sweat-inducing dogfight, ultimately it didn't matter how they killed the bandit—missile or gun—only that they did.[92]

The lesson was reinforced later that year when the Langley F-15 pilots began participating in the large Red Flag exercises conducted at Nellis AFB. The brainchild of F-4 pilot Major Richard "Moody" Suter, the Red Flag exercises were designed to replicate as closely as possible the experience of air combat. Studies had suggested that if a fighter pilot survived his first ten combat missions in Vietnam, he was more likely to survive his entire combat tour. Suter therefore pitched his idea for Red Flag to the commander of TAC,

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[91] "DACT Lessons Learned."

[92] Ibid.; *1 TFW Aerial Attack Manual, Vol. 1*, 1, 67. The F-15 pilots' reluctance to use their radars and missiles also stemmed from the cultural traditions of the F-4 Phantom community and their practice of only assessing simulated kills based on Sidewinder or gun employment, not longer-range Sparrow missile shots. See Anderegg, *Sierra Hotel*, 162–64.

General Robert Dixon, as a way to get the young pilots their first "combat" missions in a realistic but controlled training environment. Assessments of the first exercise, held in November 1975, were almost universally positive, and TAC began hosting Red Flags several times a year. One F-4 wing commander from a 1976 Red Flag described the scenario as "the closest thing to actual combat that our aircrews can experience in peacetime."[93]

Langley's Eagles arrived at Nellis in time for Red Flag VI, which began on July 8, 1976.[94] While most units were considered lucky if they were able to participate in one or two of the two-week Red Flag exercises a year, the F-15s from the 1st TFW participated in all four of the remaining Red Flags in 1976, and at least six more in 1977. The persistent presence of the Eagles was a benefit to all involved: it helped the non-F-15 units in the Air Force understand and appreciate the new fighter's capabilities, and it provided the F-15 pilots with unique opportunities to further develop and refine their tactics. Throughout the exercises, the Eagle pilots continued to experiment with different radar settings and weapons employment techniques. They tried flying at various altitudes, ranging from very high to very low. And they also tried flying in different size formations, ranging from coordinated four-ships down to autonomous singletons.[95]

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[93] *History of the Ninth Air Force, Jan - Dec 1976*, 1:173–74; "National Aeronautic Association Collier Trophy"; Arnold, "Red Flag"; Volloy, "Red Flag in Perspective"; "Dummy War at Nellis"; "'Operation Red Flag' Studies"; Hillinger, "'Russian Squadrons' Fly Mock Battles"; Michel, "Revolt of the Majors," chap. 9; Anderegg, *Sierra Hotel*, chap. 9; Michel, *Clashes*, 181, 186; Wilcox, *Scream of Eagles*. The significance of the new exercise was recognized eighteen months later when TAC and its commander Dixon received the prestigious Collier Trophy, awarded annually "for the greatest achievement in aeronautics or astronautics in America," for their role in "developing and implementing Red Flag, an unprecedented combat simulated flight training program for aircrews, ... a significant contribution to national defense." Michel argued that Red Flag and the corresponding focus on "new, innovative program[s] of realistic, combat-oriented training" was as critical a component to America's future airpower successes as the advanced technology in the aircrews' aircraft. The realism of Red Flag "combat" was reflected in its accident rate: thirty-two major accidents the first full year in 1976; more than four times the accident rate in TAC.

[94] Initially, the Red Flag exercises were numbered sequentially up through Red Flag VIII. Thereafter, the numbering scheme reflected the fiscal year, which began on October first. Hence, Red Flags 77-1 and 77-2 were both conducted in calendar year 1976.

[95] *History of the Ninth Air Force, Jan - Dec 1976*, 1:177–81; Bloomcamp, "Red Flag 77-4 After Action Report"; Miller to TAC/DOOW, "Red Flag 77-7 After Action Report"; 1TFW/DO to TAC/DOOW, "Red Flag 77-8 After Action Report"; 1TFW/DO to TAC/DOOW, "Red Flag 77-9 (Nellis) After Action Report"; 1TFW/DO to TAC/DOOW, "Red Flag 77-9 (Michael AAF) After Action Report"; 1TFW/DO to TAC/DOOW, "Red Flag 77-10 After Action Report"; 1TFW to HQ TAC et al., "RED FLAG 78-1 After Action Report"; "Air Force Eagle Joins Nellis Fighters"; Welch, Oral History Interview, 238–39; Welch, interview, July 10, 2012. Welch later commended the "unofficial testing" his pilots conducted at Red Flag and in around Langley. Langley's participation in Red Flag 77-9 was unique in that the unit was split between two locations: one group enjoying life at Nellis AFB near Las Vegas; the other deployed to the remote airstrip at Michael Army Air Field in Utah in order to demonstrate the Eagle's ability to operate out of a "bare base" location for thirty days. The troops at Michael endured "very diverse conditions, from blowing sand to three

Notably, when the Eagles did fly in formation, the wingmen didn't fly in fighting wing. The pilots who had first flown the F-15 during its testing had initially used the "tried and true" formation, but they quickly concluded that it was impractical for use in the new fighter. For starters, the wingman couldn't devote sufficient time to operating his radar when he was flying so close to his leader. The problem was exacerbated by the remarkable maneuverability of the Eagle and its "high turn and acceleration rates.... The small time delay due to a wingman's reaction time," the test pilots reported, "often left him well out of the engagement before it began." Plus, the wingman's radar transmissions tended to cause "interference" and "induced scope clutter on the leader's radar" when the two aircraft flew too close. Consequently, the early test pilots recommended that future Eagle units adopt a wider "shooter-cover position" or "fluid-two" formation similar to the "loose deuce" concept developed by the Navy for their Phantoms years earlier.[96]

The widely spaced formation, which became known simply as "tactical," quickly became the standard Eagle formation (figure 5.15). With the two fighters flying nearly line abreast, each pilot was responsible for clearing his flightmate's six o'clock position. The wingman was also encouraged to take an aggressive vertical "stack" within the formation "to increase visual acquisition problems for the enemy" while also providing options "for immediate split-plane maneuvering" and weapons employment if the Eagle element got jumped by an

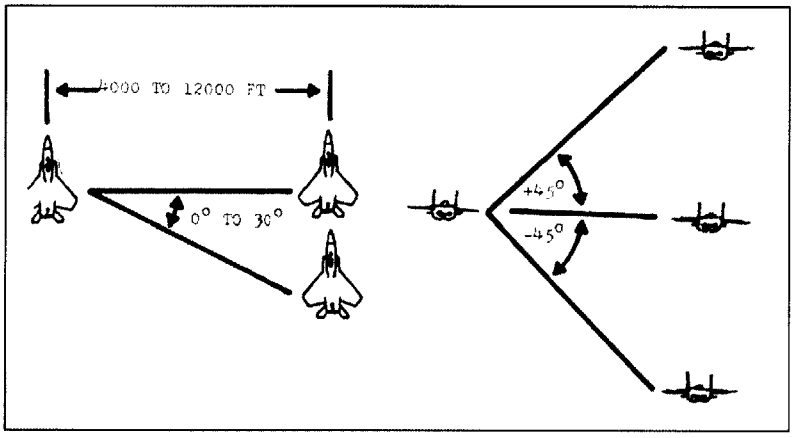

Figure 5.15. F-15 Tactical Formation.
The wingman was encouraged to fly as close to line abreast as possible so that his leader could visually clear his six o'clock position. The wingman was also supposed to "stack" either 45-degrees above or below his leader's altitude. (Source: *F-15 Conversion Training Manual*)

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days of rain to coyotes, rattlesnakes and scorpions." Bolinger, "F-15 Operates out of Desert." While some Eagle pilots preferred flying at low altitude during the Red Flag missions as a way to minimize their chance of being detected by the adversaries, others found that the "problems of navigation, formation flying, visual search, and radar search in the low-altitude, high speed arena taxes the pilot considerably." On the Eagle pilots' training experiences flying against other units near Langley, see, for example: Jaquish to 1 TFW/DO, "DACT OPS Summary"; Fanelli to 1 TFW/DOW, "Beaufort MCAS DACT Operations Summary."

[96] Flood and Rodero, *F-15 Initial Operational Test and Evaluation—Air-to-Air*, A–25, A–85.

adversary. Importantly, there were no strict, pre-assigned "shooter" or "looker" responsibilities; each flight member was expected to contribute both offensively and defensively as the situation presented itself. Finally, to alleviate the "inherent maneuvering problems" associated with the line-abreast, two-mile-split formation, a series of "specialized, prebriefed procedures" were developed for use by the pilots. For example, to turn the formation ninety degrees, the pilot on the inside of the turn was told to delay his turn until the outside fighter had nearly completed his maneuver; when the turns were properly timed, the formation would roll out on the desired heading in the same formation, albeit with the wingman now on the opposite side of his flight lead (figure 5.16).[97]

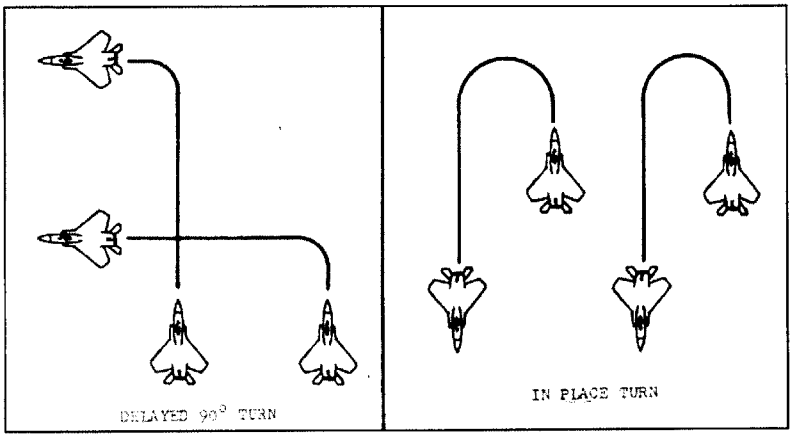

Figure 5.16. F-15 Tactical Formation Turns.
(Source: *F-15 Conversion Training Manual*)

Unlike the rancor that had erupted earlier in the Phantom community when pilots expressed an interest in adopting a non-fighting wing formation, the transition to tactical in the F-15 was surprisingly affable. Sokol witnessed the adjustment first-hand. Before he was assigned to Nellis and roped into supporting ACEVAL, Sokol was one of the first F-15 instructor pilots at Luke AFB. He remembered, "We had a clean sheet of paper. We didn't have any rules." Furthermore, "We didn't have any generals that had been in F-15s and 'knew' how to do it." Consequently, the young instructors, emboldened by the F-15's test reports, decided to throw "that fighting wing crap out with the garbage.... The logic was we're spending so much money on all this ... radar [equipment in the Eagle], ... so let's let a guy use it."[98] Coincidentally, the F-4 community was also in the process of discarding

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[97] *F-15 Conversion Training Manual*, 27–29; Anderegg, *Sierra Hotel*, 59–60. The next step was developing a procedure that would allow the formation to execute a turn without relying on a radio call from the flight leader; see Jumper, "COMM-OUT Turns."

[98] Sokol, interview. When the Air Force started soliciting applicants for the initial F-15 cadre, Sokol was working fourteen-hour days and flying two weekends a month as an F-4 instructor at George AFB, California. He scribbled out his application, but got frustrated mid-way through when it asked for his nationality and religion, information that the Air Force obviously already had on file. "I grabbed a big red marker and I wrote

fighting wing at the time, and so while the arrival of the new F-15 probably helped as Sokol indicated, it was also true that the aircrews were no longer overwhelmed with the exigencies of war and the pressures of training countless replacement pilots for short combat tours in the Phantom.[99]

Welch noted that the advantages of the new "tactical" formation became immediately obvious to the pilots at Langley during their training sorties. "If we had spread wide enough [apart in formation], there was a good chance [the opponent] would miss one of us." Plus, it gave both pilots the freedom "to exploit their airplane" and take full advantage of the Eagle's superior maneuverability without worrying about immediately running into a flightmate. Sokol, however, took note of the important implication embedded within the new formation: "Now the task is for both guys to use their head and their radar."[100]

Whether flying alone or in tactical formation with another Eagle, a consistent lesson learned in nearly all of the missions at Red Flag, as well as the training flights off the coast of Langley, was that in a multi-bogey environment, the F-15 pilot was usually much better off avoiding the turning dogfight for which his aircraft was purpose-built. One post-Red Flag report noted, "Emphasis must be placed on high-speed, minimum-turning [fights]." Another report explained that "high speed, straight dashes, with hard turns (+5.0G) proved to be effective" for the F-15. While the pilots' experiences had not totally invalidated the principle of dogfighting—many an Eagle pilot appreciated the impressive maneuverability of his jet when he suddenly detected an opponent trying to sneak into position behind him—the iconic dogfight was losing its appeal as the preferred method of initiating and succeeding in air combat.[101] It was a remarkable change in expectations, both of the technology and the pilot. Across the flightline at Nellis in 1977, the pilots and analysts working on AIMVAL-ACEVAL were learning a similar lesson.

Polish for nationality. And I wrote Druid for religion." After he was selected for the Eagle assignment, Sokol's commander told him, "You will never know how much good that did you."

[99] On the "death of fighting wing" in the Phantom community, see Anderegg, *Sierra Hotel*, 59–60, 83–85; Gish, "F-4 Air to Air Training."

[100] Welch, interview, October 1, 2013; Sokol, interview.

[101] Bloomcamp, "Red Flag 77-4 After Action Report," 4; Jaquish to 1 TFW/DO, "DACT OPS Summary," 3; 1TFW/DO to TAC/DOOW, "Red Flag 77-8 After Action Report," 7; 1TFW/DO to TAC/DOOW, "Red Flag 77-9 (Michael AAF) After Action Report," 10; Anderegg, *Sierra Hotel*, 164.

AIMVAL-ACEVAL

The immediate motivation behind the AIMVAL and ACEVAL tests was the Air Force's and Navy's desire to develop an updated IR-guided missile to complement their new solid-state AIM-7F Sparrows for use on their Eagle and Tomcat fighters. The Air Force was initially interested in a "low cost, light weight, simple and effective" missile, appropriately named the "CLAW." The Navy, on the other hand, was working on its technologically exquisite, wide-angle seeker, helmet-cued, and thrust-vectored AIM-95 Agile missile. The Navy, long pursuing its own line of Sidewinders independent of the Air Force, had also initiated development of a new L-version of the AIM-9 to help "bridge the gap" between its then-current Sidewinder and its planned Agile. The major improvement in the AIM-9L was a more sensitive, cryogenically cooled, indium antimonide (InSb) seeker, which allowed the missile to detect a target from any angle, not just from within thirty degrees of the target's tail as with the prior Sidewinders and IR-guided Falcons.[102]

However, in 1975, Congress balked at funding the services' various, competing IR-guided missile programs. It directed the Air Force and Navy, through the Defense Department's Director of Defense Research and Engineering (DDR&E), to explore and then agree upon a common short-range air-to-air missile (SRAAM).[103] DDR&E in turn then asked the services to also develop a model of air combat that would help inform the military's planning estimates for future fighter requirements—most agreed that an F-15 or F-14 was more capable than an F-5, but nobody knew how to quantify the advantage, e.g. was

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[102] Westrum, *Sidewinder*, 191; Partin, "Program Management Directive for Project 670E," 2; Griffith, "AIMVAL-ACEVAL," 24; Beck, "State of the Art"; Currie, "Statement of the Director of Defense Research and Engineering," 456; Waterman, "Research, Development, Test, and Evaluation, Navy," 794–97; "Department of the Navy, Procurement," 572–73; Lake, "ACEVAL-AIMVAL Program Review," 5040; Hildreth, Oral History Interview, 160–61; Van Dyke, "Sidewinder Program Review," 5013–38; Welch, interview, July 10, 2012. Welch explained that the Navy designed the AIM-95 to be highly maneuverable to compensate for the restricted turning performance of their F-14 Tomcat.

[103] "Advanced Short Range Air-to-Air Missile Technology," 29370; Lake, "ACEVAL-AIMVAL Program Review," 5040, 5048–49; Currie, "Statement of the Director of Defense Research and Engineering," 456; Waterman, "Research, Development, Test, and Evaluation, Navy," 794–96. Incorporating so many radical technologies, it was recognized that the Navy's Agile missile was going to be expensive. In his 1973 testimony to the House Subcommittee on Appropriations, Malcolm Currie, the director of DDR&E, emphasized his concerns with the $298 million Agile program, stating, "Estimates indicate that at least a 20-percent reduction (preferably 40 percent) would be necessary to enable procurement of the missile in large quantities." The SRAAM (Short-Range Air-to-Air Missile) is not to be confused with the Air Force's AGM-69 SRAM (Short-Range Attack Missile), the latter "a [nuclear] air-launched, air-to-surface missile" developed for the B-52G/H and FB-111. Glasser, *Hearings on Military Posture*, 3613–16.

one F-15 equal to two F-5s? Three? Four?[104] The test evaluating the different SRAAM concepts became AIMVAL; the latter force-ratio test, ACEVAL. Both were to be administered and conducted by a joint Air Force and Navy test force operating out of Nellis. They were slated to begin flying in 1976.

The two services recognized immediately that the results from AIMVAL and ACEVAL would define at a minimum the military's next-decade's worth of investment in air combat capabilities. The services also quickly recognized that while they were ostensibly working together under a Congressional and DDR&E mandate to define future air combat requirements, and despite the fact that the Eagles and Tomcats would never be in the air at the same time facing the opposing forces, the coincident matchup of the Air Force's and Navy's aircrews and equipment would inevitably invite public comparisons. More than bragging rights were at stake. Future Air Force and Navy aircraft procurement schedules, as well as potential foreign sales, hung in the balance.[105]

To help balance service interests and quash any potential accusations of service parochialism, DDR&E split administration of the tests between the two services: a Navy admiral was appointed to serve as the Joint Test Force (JTF) Test Director , the Deputy Test Director was an Air Force general. Nevertheless, worries of military or contractor impropriety were frequently voiced on Capitol Hill, which the senior officers tried to allay by stressing the "complete objectivity" of "the test plan, the test data requirements, and the manner in which the data will be handled and analyzed." The quintessential element underlying their promises of "objectivity" was the ACMI pod mounted on each test aircraft.[106]

Prior to ACMI, the results of an air combat engagement (in a training environment) were often decided based on individual pilot recollections and the occasional snippets of gun-camera footage. After an air-to-air mission, the pilots from both the "Red" (adversary)

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[104] *History of the Air Force Test and Evaluation Center, 1 Jan - 31 Dec 1976*, I:213–14; Fay, "AIMVAL-ACEVAL Program Review," 1977, 4569; Anderegg, *Sierra Hotel*, 159.

[105] COMNAVELECSYSCOM to CSAF and CNO, "Joint Test Director Sends: ACEVAL/AIMVAL Joint Test"; ADTC/XR to AFSC/TEV, "ACEVAL-AIMVAL Test Plans"; "F-15s, F-5Es Catching Up with F-14"; Knight, Oral History Interview, 232. On the importance of casting the F-15 in the best light possible, see: Marsh to AFTEC/CC, "AFSC Review of ACEVAL/AIMVAL Preliminary Test Plan," 2; Swarts, "Interest Paper on AIMVAL/ACEVAL," 3; CSAF/XO to TAC/CV, "AIMVAL/ACEVAL F-15s."

[106] Lake, "ACEVAL-AIMVAL Program Review," 5039, 5056; Fay, "AIMVAL-ACEVAL Program Review," 1977, 4579; Hildreth, Oral History Interview, 161.

and "Blue" (friendly) forces would gather in a conference room and engage in a spirited discussion over who was where when, who shot whom, and with what type of simulated weapon. "We'd have lots of arguments about what happened," Welch remembered of the typical debrief, and they weren't always grounded in reality. Jere Wallace, another of the eight AIMVAL-ACEVAL Eagle pilots, noted that winning the debrief was all about telling a believable story, "If you could lie better than anybody else, they couldn't refute you."[107]

Cubic Corporation's ACMI system for the first time offered truth data to replace the pilots' sometimes hazy and often contested memories. The system served two purposes. First, with ACMI, it was possible to determine the relative position and attitude of each aircraft, up to a maximum of eight, in the fast-changing air combat environment. Each ACMI pod was the size of a Sidewinder missile and contained its own air data sensor and inertial navigation unit. A radio transponder in the pod linked it to a network of ground monitoring stations, which, when combined with the data from the other pods on the other participating aircraft, allowed observers to watch the engagements unfold in real-time on a "three-dimensional interactive graphic display screen" (figure 5.17.) The engagements could also be recorded for later playback during the aircrews' debrief.[108]

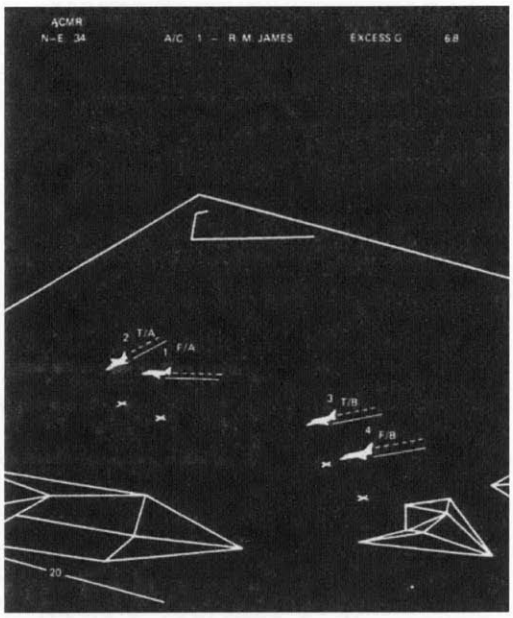

Figure 5.17. ACMI Graphic Display.
(Source: Quick, "Cleared in Hot," 12)

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[107] Welch, interview, October 1, 2013; Wallace, interview; Anderegg, *Sierra Hotel*, 104. Alluding to a fighter pilot's propensity to use his hands to reconstruct the motion of the fighters during the fight, Welch explained, "If you could get your hand back [farther than the other guy], then you could turn tighter." Anderegg noted, "No one can lie to himself better than a fighter pilot about to pull the trigger."

[108] Quick, "Cleared in Hot"; Turner, "ACMI Update"; "Dogfight Pilot Training at Nellis"; "Nellis Pilots Given New Battle Training"; Momyer, *Air Combat Maneuvering Range*; *History of the Air Force Test and Evaluation Center, 1 Jan - 31 Dec 1976*, I:218–19; Taylor, "Air Combat Maneuvering Instrumentation"; Everson, *AIMVAL Final Report*, 7–10. The actual ACMI pods mounted to each aircraft were officially termed the AIS (Airborne Instrumentation System). Heeding the recommendations of the Ault report, the Navy initiated development of ACMI—their initial version was called ACMR (Air Combat Maneuvering Range)—as a tool to help pilots visualize weapons employment zones. On concerns about ACMI's accuracy for the AIMVAL-ACEVAL tests, see Marsh to AFTEC/CC, "AFSC Review of ACEVAL/AIMVAL Preliminary Test Plan." The Air Force was also in the process of constructing an East coast ACMI range for use by both Navy and Air Force aircraft,

Second, because the ACMI pod also monitored its aircraft's weapons systems and avionics, it could report the precise settings and parameters of the aircraft's radar and weapons, including even the power level across the seeker in the nose of the Sidewinder—the volume level of its "growl." Consequently, the ACMI system could determine who was shooting at whom and with what type of weapon. When a simulated missile launch was reported, ACMI automatically calculated the probability of missile success based on the specific engagement parameters such as range to the target, aspect angle, altitude, and closing velocity. If the ACMI system predicted a kill, "a schematic coffin appeared over the victim" on the ground display, prompting test controllers to notify the appropriate pilot that he had been killed. Even though ACMI necessarily retained a certain degree of artificiality in its weapons simulations, the results quickly became recognized as an objective, unbiased estimate of the engagement outcome and a significant advance over the subjective, argumentative approach that had characterized prior assessments of simulated air combat. The only way to get a more "exact answer" from the test, AIMVAL-ACEVAL officials proudly noted, would be to "fire real missiles."[109]

For all of its advantages, ACMI had a significant drawback, though. It only worked over an instrumented range dotted with special ground receivers that could communicate with the transponders in the pods on the exercise aircraft. At the time of AIMVAL-ACEVAL, there was only one functioning ACMI range, located forty-miles north of Nellis, and it only covered a cylinder approximately thirty miles in diameter above approximately 3,000 feet AGL. Because the AIMVAL test was designed to evaluate short-range, IR-guided air-to-air missiles, it was determined that the diminutive range space would not significantly bias that test. However, several in the Air Force and Navy worried that the limited range

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which became operational in early 1977. See: Husted, "1st TFW Inherits Pilot Training System"; Waddell, "ACMI Improves Pilot Combat Training."

[109] Fay, "AIMVAL-ACEVAL Program Review," 1977, 4574–75; Anderegg, *Sierra Hotel*, 109; Quick, "Cleared in Hot"; Turner, "ACMI Update"; Risner, Oral History Interview, 182; Dvorchak, interview. To accurately predict the weapons' probability of kill, the vulnerability of the target aircraft had to be incorporated into the ACMI model. However, this threatened to introduce service bias into the ideally objective Pk tables. For example, Air Force officers argued that the F-15 was less vulnerable than the Navy's F-14; the Navy obviously argued the reverse. To resolve the dispute, a neutral vulnerability model based on an out-dated F-4E aircraft was used for both the F-15 and F-14 during AIMVAL-ACEVAL. Understandably, the conservative decision did not placate Air Force officers. See TAC/DR to AFTEC/CC, "ACEVAL/AIMVAL Preliminary Test Plan Review"; Marsh to AFTEC/CC, "AFSC Review of ACEVAL/AIMVAL Preliminary Test Plan." The pilots complained that the red forces' missiles were uncharacteristically effective—Sokol said the Aggressors were given "hittles" instead of "missiles." Sokol, interview.

space would significantly hobble the second test, ACEVAL, and its examination of force-ratio effects on air combat. But, after having delayed the two tests for almost a year while waiting on ACMI, there was little stomach in the Pentagon for postponing the tests further to gain a larger ACMI test-space. Congress demanded the test results and the services needed to deliver them if they hoped to gain the funding their acquisition plans required.[110]

To mitigate ACMI's limitation, the JTF devised a test scenario that included a VID requirement.[111] While the experience of Vietnam provided the obvious historical justification, neither the Navy nor the Air Force was too keen to see a VID restriction inserted into AIMVAL-ACEVAL. Many in both services considered VIDs a relic of the strange circumstances of Vietnam and unrealistic in the coming war they expected to fight against the Soviets in the skies over central Europe. Nonetheless, in an effort to quickly bolster its prized aircraft's VID capabilities, the Navy announced that it was going to install a Television Sight System (TVSU) on its AIMVAL-ACEVAL F-14s. The new optical tracking system promised to extend the Tomcat aircrews' ability to VID a target out in excess of five miles. The Air Force, having earlier decided against installing McDonnell Douglas's EOIATS on their Eagles, protested against the Navy's potential technological advantage, arguing that it would upset the "established balance" between the tests' objectives and constraints.[112] The Navy prevailed and its Tomcats arrived with the new system. The Air Force pilots responded with their own VID-enhancing equipment, installed just in time for ACEVAL. Known as the "Eagle Eye," the simple system consisted of an off-the-shelf six-

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[110] ACEVAL AIMVAL JTF to CSAF et al., "ACEVAL-AIMVAL Monthly Progress Report (as of 6 Jan 76)"; Fay, "AIMVAL- ACEVAL Program Review," 1977, 4571.

[111] Dvorchak, interview; Sparks, interview. To enforce aircrew adherence to the VID restriction during the tests, officials planned to have "random nonexercise [friendly] aircraft in the exercise area." Shooting down one of the "nonplayers" would, according to one Air Force general, result in "a bad day" for the offending aircrew. Lake, "ACEVAL-AIMVAL Program Review," 5043; Fay, "AIMVAL-ACEVAL Program Review," 1977, 4571–72.

[112] *History of the Air Force Test and Evaluation Center, 1 Jan - 31 Dec 1976*, I:216–17; TAC/DR to CSAF/XOO, "ACEVAL/AIMVAL Test Constraints"; Blesse, Corona Ace Oral History Interview, 82–87. A similar inter-service disagreement emerged over the use of RHAW (radar homing and warning) equipment during the tests. The Air Force's F-15s did not have their RHAW (or later RWR) systems installed yet. The Aggressors wanted a RHAW capability that mimicked the system used by the Soviet MiG-21. The services objected, but the Aggressors prevailed, and they were given a "pseudo-RHAW" capability for the tests. See: *History of the Air Force Test and Evaluation Center, 1 Jan - 31 Dec 1976*, I:215–16; ACEVAL AIMVAL JTF to CNO, "F-14/F-15 Use of RHAW in ACEVAL-AIMVAL"; ACEVAL AIMVAL JTF to AIG, "AIM-7F Kill Removal/F-14 RHAW"; ACEVAL AIMVAL JTF to CNO and CSAF/XOO, "ACEVAL-AIMVAL Initial Starting Conditions"; TAC/DR to AFTEC/JT, "F-14/F-15 Use of RHAW in ACEVAL/AIMVAL."

power rifle scope mounted next to the F-15's HUD (figure 5.18).[113] After the tests, both the TVSU and the Eagle Eye were widely deployed on the Navy's Tomcats and the Air Force's Eagles, respectively.

The inter-service squabbling over the tests' constraints and restrictions wasn't limited to the VID requirement, either. Both the Air Force and the Navy lodged repeated complaints regarding the tests' orchestration and its statistical design. Some even grumbled that because the tests weren't using real missiles, the aircrews would be at a disadvantage because the pilots wouldn't have the opportunity to see and react against a missile smoke trail heading toward them.[114] "The guys who conceived and designed the whole test series clearly didn't know what they were doing," one Navy official bemoaned.[115] When they were unable to satisfactorily correct for the inherent artificiality of the tests, many officers in both services began to emphasize the "imperative that the impact of the test constraints be highlighted." For example, officials in the Air Force's Studies and Analysis branch issued a cautionary critique: "ACEVAL and AIMVAL are tests involving only close-in, visual air-to-air combat involving flight sizes no greater than four. The test should not be advertised as something it is not."[116] Lieutenant General Alton Slay, the Air Force Deputy

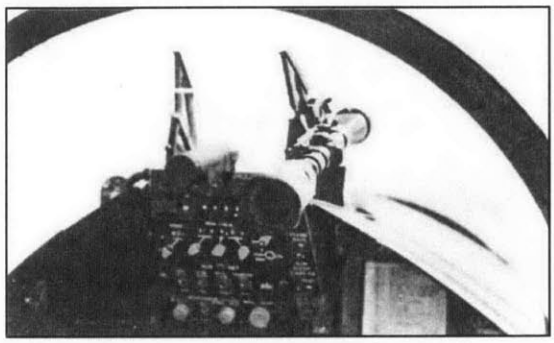

Figure 5.18. F-15 "Eagle Eye."
The six-power rifle scope mounted next to the HUD could theoretically "more than double unaided visual identification ranges." The cylinder mounted in the center of the HUD was the HUD-camera. The black area to the left of the center-mounted radio and HUD controls is the VSD. (Source: O'Keefe, "Eagle Eye," 29)

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[113] Everson, *ACEVAL Final Report*, 4; O'Keefe, "Eagle Eye"; Anderegg, *Sierra Hotel*, 161. Blesse was not a fan of the "Eagle Eye" solution, remarking, "The [F-15] is a single-seater fighter with a million different things to do, so now you are going to give the pilot a monocular and let him try that too.... That is like giving him 15 different things and then sticking a broom in his ass and telling him to sweep the floor while he does those other 15 things." Blesse, Corona Ace Oral History Interview, 84–85.

[114] See arguments in: SAF/SA to AFTEC/CC, "Review of ACEVAL-AIMVAL Preliminary Test Plan"; TAC/DR to AFTEC/CC, "ACEVAL/AIMVAL Preliminary Test Plan Review"; Fay, "AIMVAL-ACEVAL Program Review," 1978, 5202–3, 5220–21; Kross, *Military Reform*, 104–5; Lake, "ACEVAL-AIMVAL Program Review," 5041, 5049; ADTC/XR to AFSC/TEV, "ACEVAL-AIMVAL Test Plans."

[115] Haering, "Aim/Ace," 15.

[116] TAC/DR to AFTEC/CC, "ACEVAL/AIMVAL Preliminary Test Plan Review"; SAF/SA to AFTEC/CC, "Review of ACEVAL-AIMVAL Preliminary Test Plan." One Air Force officer succinctly captured the coming dilemma: "The large scale of the test itself, number of trial repetitions, and bounty of data tend to create the impression that the test results can be taken at face value. Characteristic of such a notion is the attitude that

Chief of Staff for Research and Development, shared the sentiment with Congress, reminding the members of the Senate Armed Services Committee in his testimony on March 9, 1977, that, having "theoretically taken a big skyhook and dropped these airplanes into a 30-mile arena," the test was "a canned situation" and should not be taken as an absolute indicator of air combat performance.[117]

Although initially slated to be conducted after ACEVAL, AIMVAL was conducted first. The evaluation began on January 3, 1977, and continued for more than five months before terminating on June 24. Its stated objective was to "compare the operational utility of existing and proposed short-range air-to-air missile concepts [with respect to] sensitivity [and] off-boresight [capability]."[118] During the test, five separate short-range, IR-guided missile designs, ranging from simple, boresight-only missiles to an extremely sensitive, high-off-boresight, helmet-cued AIM-95 Agile-type weapon, were evaluated on both Navy F-14 and Air Force F-15 aircraft over a course of 1,033 trials.[119] In addition to the simulated infrared concept missiles, the Blue forces were also armed with simulated AIM-7F Sparrows and a simulated 20-mm gun. In an effort to help boost the performance of its Eagles in the anticipated dogfight environment of AIMVAL, the Air Force also added a third "vertical scan" auto acquisition mode to its F-15s, in which the radar antenna searched only in elevation, from +5 to +45 degrees, centered along zero-degrees azimuth (in line with the aircraft's nose).[120]

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what came out of the test must be right, since we did so much of it and the results did not change." Welch to AF/XO, "AIMVAL Analysis and Evaluation," 2.

[117] Fay, "AIMVAL-ACEVAL Program Review," 1977, 4571. The Joint Test Director tried to assuage the services' concerns, explaining shortly after AIMVAL began, "The majority of the test results and relative effectiveness conclusions [*sic*] ... should not be treated in terms of specific system absolutes." *History of the Air Force Test and Evaluation Center, 1 Jan - 31 Dec 1977*, I:271.

[118] Fay, "AIMVAL-ACEVAL Program Review," 1977, 4565. An off-boresight acquisition capability allows the pilot to cue his missile, usually using the radar, to a target that is not directly in front of the aircraft.

[119] Everson, *AIMVAL Final Report*, 5–7, 13–14; Tissot and Hildreth, *AIMVAL Final Report, Vol. 1*, III–1–3. Each trial required multiple Blue fighters (F-15s or F-14s) and Red fighters, but multiple trials could also be accomplished on a single sortie. Hence there is no easy correlation between trials and sorties required: a total of 2,678 sorties were flown during AIMVAL.

[120] *T.O. 1F-15A-1-1*, 1–27; *T.O. 1F-15A-34-1-1*, 1–58. To make room for vertical scan in the HOTAS scheme, the engineers "moved" supersearch to the forward position of the auto acquisition switch—subsequent forward switch actuations would toggle between supersearch and boresight. Vertical scan took the old supersearch position, aft on the auto acquisition switch (see figure 5.12). Additionally, in preparation for AIMVAL, the F-15's CC also had to be purged of all air-to-ground weapons information to free-up memory and computing power to calculate the new weapons parameters for the various missile concepts, including the new AIM-9L.

Opposing the F-14s and F-15s were Air Force and Navy Aggressors flying F-5E aircraft armed with a modified, boresight-only version of the AIM-9L Sidewinder, an approximation of a future 1985 Soviet threat.[121] Force ratios during the trials varied from one-versus-one to two-against-four, with the Blue forces never outnumbering the Red Forces. The JTF's *AIMVAL Final Report* characterized a typical engagement: "Trials commenced at predetermined geographical range start points; both sides were on a fighter sweep mission. The usual engagement pattern was an ingress phase with head-to-head approaches, a large initial exchange of missiles at visual identification, real-time kill removals and re-engagements/disengagements until all aircraft had been killed or the surviving aircrews had exited the range."[122]

After AIMVAL, officials declared the test a "positive influence toward the resolution of common Air Force and Navy needs" for the next SRAAM.[123] Moreover, rather than simply putting all the aircraft and missile data "in a computer, kick[ing] that computer and hav[ing] it spit out a roll of tape that tells you what the outcome was," Slay told Congress that AIMVAL allowed the services to capture the "extremely important … human factor" that dramatically influenced the real-world performance of their complex weapons.[124] Of the IR-guided missile concepts tested, however, none were judged satisfactory; the tested missile seekers all exhibited difficulty distinguishing between the fighter targets and the hot desert background. Additionally, although intended to dictate future *IR-guided* missile requirements, many thought the results from AIMVAL demonstrated a compelling need for new high-speed, multi-targetable, medium-range *radar-guided* air-to-air missiles. Most significantly, AIMVAL vividly illustrated that a relatively simple foe armed with an all-aspect, fire-and-forget missile like the AIM-9L could be lethal to advanced US fighter aircraft.[125]

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[121] Lake, "ACEVAL-AIMVAL Program Review," 5052; Fay, "AIMVAL-ACEVAL Program Review," 1977, 4573.

[122] Tissot and Hildreth, *AIMVAL Final Report, Vol. 1*, III–6. Of note, an F-15 and an F-5E collided during AIMVAL. The F-15 was destroyed; the F-5E managed to land safely; both pilots survived. The mishap was subsequently cited as indicative of the realism of the test; see: "Nellis Fighters Collide"; "Two Jets Collide"; Hildreth, Oral History Interview, 172; "No-Win War at Dogbone Lake"; Kaylor, "Mock Dogfights Test Latest Jet Fighters."

[123] *History of the Air Force Test and Evaluation Center, 1 Jan - 31 Dec 1977*, I:273.

[124] Fay, "AIMVAL-ACEVAL Program Review," 1977, 4578.

[125] Fay, "AIMVAL-ACEVAL Program Review," 1978, 5206–8, 5225; Newell, "AIMVAL-ACEVAL Results," 1; Welch, interview, June 8, 2012; Tissot and Hildreth, *AIMVAL Final Report, Vol. 1*, V–1. In his 1976 testimony, Rear Admiral R.P. McKenzie predicted that the "all aspect, close in" AIM-9L missile would

Although focused on a different question, ACEVAL supported many of AIMVAL's earlier recommendations. Executed between June 2 and November 10, 1977, ACEVAL's stated objective was to "evaluate the factors which affect the outcome of multiple aircraft engaged in close-in air combat between specific aircraft [as a function of] force size/ratio [and] initial conditions."[126] ACEVAL used the same AIMVAL test management structure, much of the same Air Force F-15 and Navy F-14 equipment, and many of the same aircrews. The F-5E-equipped adversary also remained the same as during AIMVAL. Whereas variation in AIMVAL was primarily due to the five missile concepts tested, during ACEVAL all of the F-14s and F-15s used the same simulated armament: AIM-9Ls (AIMVAL Concept C), AIM-7Fs, and 20-mm guns. Variation during the 720 trials of ACEVAL was instead primarily a function of setup parameters: force ratios varied from one-against-one to four-against-four, with Blue forces never outnumbering Red forces; the availability of radar ground controllers varied from both sides having control to only one side (either Red or Blue) having control; and the starting positions of the Red and Blue forces varied among twenty-seven different options within the thirty-mile ACMI range (figure 5.19).[127]

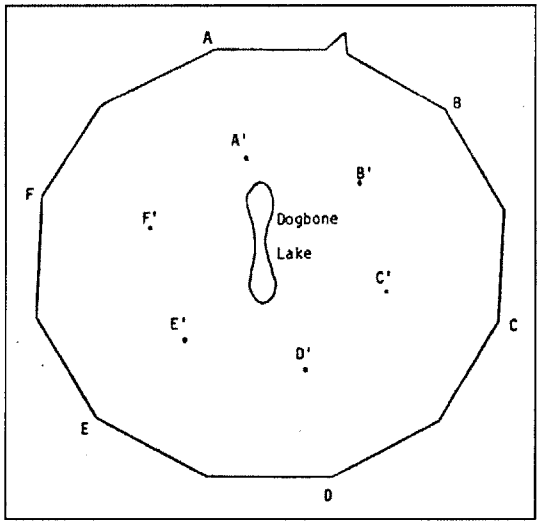

Figure 5.19. Nellis ACMI Range Starting Points, ACEVAL.
The outer circle measured thirty miles in diameter; the inner-circle, fifteen miles. Aircrews were positioned at the specific reference points on the inner or outer circle according to the test matrix. (Source: Everson, *ACEVAL Final Report*, 9)

According to Stephen "Shad" Dvorchak, a former F-100 and F-4 pilot and a data analyst during the two tests, the findings from the four-month-long ACEVAL test could be captured in a single sentence: "As the number of fighters in an engagement

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"revolutionize fighter tactics"—AIMVAL seemed to prove him right. *Hearings on S2965*, 5028. See also Blesse, Corona Ace Oral History Interview, 68–74.

[126] Fay, "AIMVAL-ACEVAL Program Review," 1977, 4565.

[127] Everson, *ACEVAL Final Report*, 8–10, 28; McKenzie and Hildreth, *ACEVAL Final Report, Vol. 1*, III–1–3. During ACEVAL, the F-14s retained their helmet-mounted cueing system and their TVSU equipment from AIMVAL; the F-15s did not use the helmet cueing system but added their "Eagle Eyes" to their aircraft to assist with long-range VIDs. A total of 3,222 sorties were flown during ACEVAL.

increases, the exchange ratio trends toward One."[128] In other words, the larger the fight (up to the tested maximum of four-against-four—the ACMI limit of eight total aircraft), the more likely everybody died, regardless of their technological sophistication or lack thereof. Moreover, Dvorchak noted that any attempt to view the ACEVAL results strictly in terms of competing technological hardware quickly became "incomprehensible."[129] It appeared that after spending almost a year trying to quantify air combat, the test administrators could only conclude that "some data is [*sic*] worthwhile," mostly the "aircrew-in-the-loop factor."[130]

Eventually, the public would learn of the AIMVAL-ACEVAL results within the context of the broader defense reform movement in the US during the early 1980s.[131] Typifying the popular backlash against the costly, technologically advanced but apparently inadequate Air Force and Navy fighters, the *Chicago Tribune* reported in December 1981 that "The proud 'air superiority fighters,' F-15s and F-14s, ... had been fought to all but a draw by a comparatively crude $4 million airplane, the F-5." The "Reformers" argued that a fighter like the F-5 used in AIMVAL-ACEVAL, armed with cheap but lethal short-range IR-guided missiles and a powerful gun, provided just-enough technology to answer America's

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[128] Dvorchak to Fino, "Re: Hi Shad!". Dvorchak's assessment is confirmed in: Fay, "AIMVAL-ACEVAL Program Review," 1978, 5211–12; Newell, "AIMVAL-ACEVAL Results," 2. Drawing laughter from his Congressional audience, Fay commented during his testimony, "I would like to point out, sir, that we spent 2 years getting prepared for ACEVAL, 6 months running the test, 2 days to reduce this data, and 2 months to figure out how to say it, sir."

[129] Watts, "Doctrine, Technology, and War," n65.

[130] Fay, "AIMVAL-ACEVAL Program Review," 1978, 5217. While the tests yielded a great deal of information about short-range air combat, the test officials realized that they had analyzed "perhaps [only] 2 inches on the yardstick of air superiority." Additionally, although concluding that "numbers are the determining factor in the outcome of air combat," they still did not understand "what caused numbers to be so important." Later analysis revealed that in fact "quantifiable variables such as numbers only accounted for about 10-20 percent of the variation in outcomes, whereas human factors [such as situational awareness] had 'more than five times the effect on results.'" See Fay, "AIMVAL-ACEVAL Final Report Briefing," 435; Watts, *Six Decades of Guided Munitions*, 50; Welch to AF/XO, "AIMVAL Analysis and Evaluation," 2–3; Fay, "AIMVAL-ACEVAL Program Review," 1978, 5212. On the importance of situational awareness in air combat, see Spick, *Ace Factor*; Watts, "Doctrine, Technology, and War"; Watts, *Six Decades of Guided Munitions*, 49–54.

[131] The Defense Reform Movement gained significant momentum on Capitol Hill following a hearing organized by Senator Sam Nunn (D-GA) in December 1980. A few months later, a Military Reform Caucus formed under the leadership of Senator and future Presidential-hopeful Gary Hart (D-CO), whose members focused on uncovering waste and corruption in the US military. A string of disturbing defense-related mishaps, including the 1979 Soviet invasion of Afghanistan and the failure at *Desert One* in the Iranian desert in 1980, fueled the notion that America's military was indeed wrecked. Sprey and Riccioni were prominent participants in the public reform debates. Their friend and accomplice, Chuck Spinney, made the cover of the March 7, 1983, issue of *Time* with the question, "US Defense Spending: Are Billions Being Wasted?" bold in the foreground. Isaacson et al., "Winds of Reform"; Nunn, *Impact of Technology on Military Manpower*; Wheeler and Korb, *Military Reform*; Hart and Lind, *America Can Win*; Fallows, *National Defense*; Kaldor, *Baroque Arsenal*; Locher, *Victory on the Potomac*.

tactical fighter requirement to defeat the Soviet hordes, but at a much more affordable price that would finally allow the nation to field a sufficient *quantity* of aircraft. While the Reformers acknowledged that the two tests excluded the effects of longer-range air combat, they also countered that Vietnam conclusively demonstrated that the longer-range combat environment was not tactically viable—aircraft inevitably were forced to engage in close-in dogfighting even if they were not designed for it. For the Reformers, AIMVAL-ACEVAL simply provided more recent, confirmatory evidence of the dominant historical trend.[132]

Others, however, refused to accept "mutually devastating" mass dogfights as the preferred outcome for American aircraft battling for air superiority.[133] For them, the key lesson of AIMVAL-ACEVAL was not that "quantity" suddenly trumped "quality," but rather the radical, transformative effect on air combat when an opposing aircraft gained a weapon like the AIM-9L.[134] For example, Welch remarked that after observing AIMVAL-ACEVAL, he suddenly realized that "all" of the lessons that he and his fellow Langley pilots had learned during their first years flying the F-15 "went to hell when the [opponent] got the AIM-9L.... All these tactics, all of our experiences, everything we've taught each other goes out the window."[135] It was a valid assessment, although slightly overstated. As noted above, the Eagle pilots at Langley had already begun to acknowledge that their best chances at victory and survival were attained when they avoided a close-range dogfight, and that was against an adversary less capable than the one faced in AIMVAL-ACEVAL. Hence, while the two tests confirmed the pilots' initial anecdotal assessments, they also demonstrated

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[132] Coates and Neikirk, "Cheaper Jets Shoot Down Claims for New Models"; Fallows, "Muscle-Bound Superpower"; Fallows, "America's High-Tech Weaponry"; Fallows, "I Fly with the Eagles"; Spinney, *Defense Facts of Life*; Spinney, *Impact of Technology on Military Manpower*; Kent, Oral History Interview, 15–17; Welch, Oral History Interview, 147–49, 155; Michel, "Revolt of the Majors," 81.

[133] McKenzie and Hildreth, *ACEVAL Final Report, Vol. 1*, VI–30. The "mutually devastating" description was also used in one anonymous pilot's satirical summary of AIMVAL-ACEVAL that made its way onto the TAC Commander's desk. The pilot likened the tests to "A shootout in an isolated tennis court between giants armed with rifles, pistols, and knives and midgets armed with only pistols and knives.... Shootout Results: More or less as expected: Mutually Devastating." Welch to McMullen, March 8, 1977; McMullen to Dixon, March 15, 1977.

[134] They also pointed to some of the issues with the Reformers' favored "quantity" arguments, not least of which was the burdensome personnel requirements, both in pilots and ground crew, that accompanied the favored four-fold increase in Air Force combat aircraft. See Perry, *Impact of Technology on Military Manpower*, 9, 40, 48; Anderegg, "Meeting the Threat," 2, 6; Kross, *Military Reform*, 143–45; Kross, "Military Reform: Past and Present"; Slife, *Creech Blue*, 72; Correll, "Reformers," 43. One enthusiastic Air Force general reported, "ACEVAL ... strongly inferred that more quality and quantity are required." TFWC/CC to TAC/CV, "Recap of ACEVAL-AIMVAL Briefings."

[135] Welch, interview, July 10, 2012.

rather conclusively that the close-range environment was about to become even more lethal. The Air Force and the Navy therefore concluded that they had to find a way to keep their fighters out of the short-range environment.

Their longer-range, radar-guided AIM-7 Sparrows were not going to provide the answer, though. Even when the AIM-7 was fired at its maximum range, the attacking pilot still often found himself less than three miles from his target by the time the missile actually hit—a function of the Sparrow's requirement for the attacking aircraft to remain pointed at and illuminating the target with its radar throughout the missile's entire time-of-flight. In the past, it hadn't mattered. Enemy fighters didn't possess an all-aspect-capable IR-guided missile that could detect and track an approaching target, and, if the enemy pilot tried to shoot one of his radar-guided missiles (which were shorter-range and considered less-capable than the Sparrow), as long as the American Sparrow arrived first, the enemy's missile would lose its source of radar guidance and veer off course. Now, armed with an all-aspect AIM-9L-type missile, even though the opponent probably would not survive the Sparrow attack, as long as he pressed his pickle button and launched a self-guiding IR-missile before the Sparrow arrived, there was a good chance he would at least even the score. One AIMVAL-ACEVAL analyst succinctly described the new reality, "If you've got an AIM-7, you're going to die."[136] Because limitations in IR-seekers precluded development of a longer-range, IR-guided missile, the Air Force and the Navy concluded that their aircrews needed a new, radar-guided missile, one that didn't rely on the aircraft radar to guide it all the way to the target. The jointly developed AMRAAM quickly became one of the top acquisition priorities for the two services. The other IR-missiles were shelved in order to help free-up funds for the new fire-and-forget, radar-guided missile; all except for the AIM-9L, which the two services agreed to co-sponsor.[137]

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[136] Sparks, interview.

[137] Bond, *Advanced Medium Range Air to Air Missile*, 348–39, 358; Perry, *Impact of Technology on Military Manpower*, 5, 41; Hildreth to TAC/CV, "AIMVAL Final Report Recommendations"; Hildreth, Oral History Interview, 165–66; Pinnel, "History of AMRAAM"; TFWC/CC to TAC/CV, "Recap of ACEVAL-AIMVAL Briefings"; Fay, "AIMVAL-ACEVAL Final Report Briefing," 430; O'Hara, "Statement," 1018–27; Blesse, Corona Ace Oral History Interview, 71–72. Following a set of 1978 Congressional hearings, one Air Force officer reported that the AIMVAL-ACEVAL findings were "well received by the Congressmen and staffers" and "substantially justified the AMRAAM program in FY79 [fiscal year 1979]" Whereas AMRAAM flourished post AIMVAL-ACEVAL, the short-range, IR-guided equivalent ASRAAM (advanced short range air-to-air missile) never materialized.

The AMRAAM would not arrive for at least another decade. In the interim, the Eagle pilots had to figure out a way to transform their aircraft from a close-range dogfighter into a missile-hurling interceptor. And they had to do it while relying on an AIM-7 missile that AIMVAL-ACEVAL had shown was likely to drag them into the close-range environment and get them killed. A new set of radar "sorting" tactics, made possible only with the bounty of information provided by the Eagle's PD radar and only after the fighter pilots had abandoned the rigid formation assignments associated with fighting wing, was an essential element of the transformation. In the process, the new tactics and the skills required to execute them would profoundly alter the traditional fighter pilot experience.

"Sorting" Things Out

Fighter pilots in the Phantom, or more appropriately their GIBs, had already learned how to operate a radar. But, despite the radar set being comprised of exquisitely engineered wave guide tubes that transmitted precisely tuned electromagnetic energy for periods lasting no more than tens of microseconds at a time, the pilots' process for using their precision instrument wasn't itself very precise. Phantom crews set their radar's altitude coverage simply by judging the height of the ground return line on their radar scope. They manipulated the radar gain until they "saw something [they] liked."[138] There was no way to precisely determine a target's altitude. And, if an aircrew was able to distinguish a target's "fuzzy blip" from the array of other "fuzzy blips" on their scope, there was no guarantee that their flightmates would be able to see the same target. As a result, although there might be four Phantoms flying together in a formation and all might be searching the same piece of sky with their radar, it was highly unlikely that all four would see the same thing. Each

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There was another important component to long-range aerial combat that only a few individuals recognized at the time—the need for better EID capabilities or clearer ROE, or better yet, both. See, for example: Blesse, "Changing World of Air Combat," 36–37; Brown, "Technology, Military Equipment, and National Security," 19; Martin to Under Secretary of Defense for Research and Engineering, "AIMVAL Test Results and IFF." The incoming commander of TAC, General Wilbur Creech, also appreciated the daunting challenge. After hearing about the AIMVAL-ACEVAL results, Creech was reported as "feel[ing] that the JTF underestimated [the identification problem] by an order of magnitude.... Further he was adamant that present IFF equipment, procedures, reliability and development were inadequate." TFWC/CC to TAC/CV, "Recap of ACEVAL-AIMVAL Briefings." On later EID developments and their use in Desert Storm, see: Michel, *Clashes*, 181; Werrell, *Chasing the Silver Bullet*, 70–71; Putney, *Airpower Advantage*, 289; Carpenter, "Joint Operations in the Gulf War," chap. 3.

[138] Sokol, interview.

Phantom crew possessed a slightly different understanding of the airspace in front of them, and nobody knew whose was most accurate.

In the aerial battles over Vietnam, it hadn't usually mattered. Once the Phantoms detected a target with their radar, they were likely going to end up in a close-range battle anyways due to the VID requirement. While they would have obviously preferred to have more information on the number and location of any additional targets in the area, as long as they kept their tail clear of enemy fighters, the Phantom crews were not usually at risk of being shot down by a MiG.[139] They figured they could deal with any other MiGs as they saw them, and they were generally correct, assuming they saw them. The same strategy, however, was no longer viable when the adversary possessed an all-aspect, IR-guided missile like the Aggressors used in AIMVAL-ACEVAL. Suddenly the Eagle pilots faced a life-or-death requirement: they needed to locate *all* of the enemy aircraft with their radars before racing headlong into a close-range dogfight. A failure to account for even just one enemy bandit often resulted in, at best, a tit-for-tat missile exchange; at worst, several "dead" F-15 pilots.

Fortunately, the F-15 pilots enjoyed a clear advantage over their F-4 brethren. Capitalizing on the Eagle's PD radar and CC-controlled displays, all of the pilots in the formation were likely to see the same radar picture. A flight leader therefore had the capability to assign specific radar targets to specific pilots in the formation, expecting them to not only understand the communicated targeting scheme but also to be able to execute it. This capability went unexploited prior to AIMVAL-ACEVAL. After all, the Eagle pilots were focused on short-range combat and they were primarily using their radars as they had in the Phantom before, to help secure a positional advantage for an ensuing dogfight.

The sudden shift away from the once-favored aerial duel provided a fresh imperative to develop new coordinated tactics that would allow the pilots to exploit the common radar picture. Skill at executing these new tactics quickly became the new measure of pilot success, and a wingman that had earned a reputation for always finding his "sort" became a more precious commodity than one regarded as a good dogfighter. However, the F-15 initially lacked many of the tools needed to assess a pilot's performance executing the new tactics.

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[139] Wallace, interview. In the Phantom, "as soon as somebody got a contact, the general tendency was everybody else glommed on to that." However, Wallace explained that having multiple Phantoms lock and then launch their Sparrow missiles at a single target was not necessarily frowned upon since the missile reliability was so low.

Moreover, the new emphasis on radar interpretation and manipulation was not amenable to the classic trial-and-error training methods popular in the fighter pilot community. Hence, the introduction of the radar in the F-15 and the sudden shift toward long-range sorting tactics following AIMVAL-ACEVAL fundamentally redefined the Eagle pilot's desired skill set, the means of evaluating it, and the techniques for learning and teaching it.

New Ways to Use the Radar

As noted earlier, the first Eagle pilots considered their new look-down, shoot-down PD radar a godsend. Although they still had to manually adjust their radar antenna's elevation angle and could only search a specific swath of sky at a time, the Eagle pilots could be reasonably sure that if there was an aircraft flying within that volume of airspace, their radar would detect it.[140] But, the Eagle's radar still suffered from a fundamental limitation. The single, synthetically generated target brick that magically appeared on their VSD only provided scant information: range, relative azimuth, and a broad band of possible altitudes. To obtain more precise target information, such as the target's aspect angle and its specific altitude, the Eagle pilot had to command a radar lock. A radar lock was also required anytime the pilot wanted to employ a Sparrow missile.

If there was only a single target in the airspace, locking it would not be an issue. But, if there were known to be multiple targets in the area, or if the pilot suspected there might be multiple targets, then selecting track on a single target meant that the pilot would be unable to search for or monitor any other aircraft. As one AIMVAL-ACEVAL test official explained, going to track was like "look[ing] through a soda straw.... You get extremely intelligent about one airplane, and everybody else goes away." The question that therefore confronted the pilots was, succinctly stated, "How the [expletive] can you win a fight looking through a [expletive] soda straw?"[141]

For example, imagine an F-15 facing two Aggressors flying in a line-abreast formation. The Eagle pilot detects the two aircraft with his radar and commands track on one of them, say the target on the right. He then launches a Sparrow missile at that target. A few seconds later, the F-15 pilot observes the target aircraft turn forty degrees to the right. The target's slight maneuver would have required the Sparrow missile to expend its limited

[140] Welch, Oral History Interview, 239.

[141] Sparks, interview.

energy adjusting its flight path, potentially robbing the missile of its ability to complete the intercept. Then again, the missile might still have enough "smash" to hit the target and destroy it. There was no way for the pilot to tell. More importantly though, what about the other target that was on the left? Did it also turn? If it didn't, then it would close the distance to the F-15 faster than the target currently being tracked, which would mean that the F-15 pilot would come under attack sooner than expected. But, if the F-15 pilot elected to break the radar lock and look for the target that was originally on the left, he would certainly trash his Sparrow missile currently in-flight against the target on the right.[142] The ideal solution would be to give the Eagle pilot a semi-autonomous missile, so that he could break the radar lock without effectively discarding his missile in-flight and then use his radar to search for the target that was on the left. Another possibility would be to provide the pilot with a radar mode that could simultaneously search for targets while tracking another. Both innovations would eventually emerge—the new missile being the AMRAAM and the new radar mode being TWS (track-while-scan)—but not for several years.[143]

A third possibility that did not rely on a new missile or a new radar mode would be to trust another F-15 flying in formation to target the enemy aircraft that was on the left. The process of assigning different radar targets to different flight members became known as "sorting." The precision in the Eagle's radar and displays meant that for the first time there was a reasonable assurance that a sorting plan could be executed. Both F-15 pilots were likely to see the targets on their VSDs, and after locking their assigned targets, the

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[142] This situation might develop even during a VID-required scenario like that in AIMVAL-ACEVAL. For example, using the combination of the TD box and the Eagle Eye, five to ten mile-VIDs were not considered abnormal, but the pilot would have an extremely difficult time keeping track visually of an additional aircraft that he had no cueing for.

[143] Decades later, active electronically scanned array (AESA) radars would eliminate the single target tracking limitation of mechanically scanned radars. In the interim, TWS modes allowed a pilot to simultaneously track one target and scan a limited volume of airspace around that target; the Sparrow, however, could not be supported in TWS. Of note, the different TWS modes were entered from radar track using forward or aft actuations of the auto acquisition switch, further complicating the HOTAS switchology. Another improvement the emerged post AIMVAL-ACEVAL was the pilot's capability to manually boresight an AIM-9L, an early, rudimentary version of multi-targeting. The pilot could track one target with the radar while supporting an AIM-7 in flight, visually detect another target nearby, pull to place the second target in the middle of the HUD while depressing the AIM-9 boresight button on the right throttle (assuming that he would not exceed the sixty-degree radar gimbal on the tracked target), uncage the Sidewinder using the nose gear steering button on the control stick, listen for a good tone, and then fire the AIM-9. An Eagle pilot that could reliably accomplish the cumbersome procedure was considered "shit hot." Finally, ACEVAL also demonstrated the importance of decoy flares for the F-15 to enhance its survivability against an enemy all-aspect missiles that were already in flight. Wallace, interview; Cliver, interview; Dvorchak, interview; and Sparks, interview; Sokol, interview; Welch, interview, October 1, 2013.

pilots could use the target information that was readily displayed as "positive feedback" to determine whether or not they were sorted. For example, if one Eagle pilot said that his target was a "16-Left" and the other pilot said that his VSD indicated a target with an aspect angle of "15-Right," then the two pilots would know that they had in fact locked different targets. Alternatively, the pilots could have used the target's digital altitude read-out on their VSDs as a discriminator. While the sorting tactics had obvious shortfalls if there were more enemy targets than F-15 radars, in those situations there was an even stronger imperative to sort correctly so as to ensure that the F-15s were not inadvertently "double targeting, or double shooting, at a single target." As Wallace explained, the Eagle pilots discovered that with properly executed sorting, "You were making your firepower much more effective."[144]

In addition to the technical requirements of a more reliable radar that provided useful, digital target information, and a widely spaced formation that allowed the wingman to devote the necessary attention to monitoring the VSD inside his cockpit, sorting was predicated on a high level of mutual trust extending between flight leader and wingman. Both flight members had to possess confidence that the other was capable of working the radar and would adhere to the targeting plan. During a high stress and confusing intercept, pilots had to resist the powerful urge to lock the first target that appeared on the VSD—an "I've got mine, you go find something else" attitude.[145] That led to double-targeting and "dead" F-15s. Moreover, even assuming that the F-15 pilots had successfully sorted to their assigned targets, they still had to trust that their flightmates would complete their task and actually kill their target. Flight leads learned that they could just as easily die from their wingman's target as their own.

The Aggressors during ACEVAL tried to exploit this very possibility. Anticipating the Eagles' targeting schemes, the Aggressor pilots developed carefully scripted maneuvers purposefully designed to confuse the Blue pilots. For example, one early Aggressor tactic was known as "swap and turkey" or "rope a dope." Beginning with two widely spaced

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[144] Wallace, interview; Sokol, interview.

[145] Anderegg, *Sierra Hotel*, 160; Anderegg, interview, October 2, 2013; Sokol, interview. Anderegg described "the three keys to surviving and winning" in the Eagle as "discipline, discipline, and discipline." The "I've got mine" sort was also occasionally called the "Colonel's sort" or the "field-grade sort" because the senior officers had "a reputation for being unable to work the radar as well as the young studs"; they would tend to find a target and grab onto it, hoping that the "younger, more proficient pilots" in the formation would find the other targets.

formations, the Aggressors would send one formation charging at the Blue fighters. After anticipating that the fighters had all gone into radar track and launched their Sparrow missiles, the charging Aggressors would then abruptly turn around and lead the chasing Eagles or Tomcats into a position where the other formation of Aggressors could attack. The first time the Aggressors tried out the "swap and turkey" tactic, they claimed three of four attacking Tomcats.[146]

Many pilots complained that the Aggressors' tactics during ACEVAL were not representative of the expected Soviet threat. Simply put, the Aggressor pilots were too good and their tactics too imaginative.[147] The test's directors, however, concluded that such "tactics change for change's sake was a sound tactical principle," and that the intense competition it fostered among the aircrews helped contribute to the "realism" of the test environment. They also noted that the "ingenuity" was not limited to the Aggressors; the F-14 and F-15 aircrews quickly developed more flexible counter-tactics of their own designed to blunt the Aggressors' scripted plans.[148] In the end, it was the ensuing battle of wits and the rapid development of air combat tactics and counter-tactics that constituted the lasting legacy of the ACEVAL test.

For example, the wily Aggressor tactics illuminated a key weakness in the Eagle pilots' early attempts at sorting: their heavy reliance on sometimes imprecise radio communications. As one F-15 pilot noted, PD radars only "made one airplane smarter," somebody still needed to coordinate the multiple aircraft radars in the fighter formation. Initially during the intercept, each pilot was assigned a different sector of the sky to scan, and if they detected a target, then they were responsible for calling it out over the UHF radio. As

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[146] Sparks, interview; Wallace, interview. Wallace described the Aggressors' tactics as "effective … to prevent you from sorting, but tactically [they] weren't very salient." The Aggressors were using a "pseudo-RHAW" system to alert them of the Blue forces' targeting, which, depending on the account, either consisted of modified "fuzz-buster" radar detectors or GCI-radio calls to the Red forces whenever a Blue aircraft locked an F-5E; the latter is more likely.

[147] Sparks, interview. Sparks remembered an Israeli Air Force official came to observe the tests, watched a few engagements, and then declared that the Aggressors were "too good." The problem, Sparks noted, was that like the Blue aircrews, the Aggressors were flying nothing but AIMVAL-ACEVAL missions for almost a year, "You get pretty goddamn good [flying that much]."

[148] Tissot and Hildreth, *AIMVAL Final Report, Vol. 1*, III–6; McKenzie and Hildreth, *ACEVAL Final Report, Vol. 1*, VI–2–3, VI–30, VII–18; Everson, *ACEVAL Final Report*, 10–11; Watts, "Doctrine, Technology, and War." Everson concluded that the aircrews' ability to develop stylized tactics that maximized their advantages while negating their opponents' advantages rendered any one side's individual technological advantage ephemeral. Watts declared that the net effect was a tactical stalemate with neither side accruing a significant advantage over the other for any appreciable duration.

the Eagle formation closed on the target(s), the flight leader would communicate the common, assembled radar picture and direct the flight members' targeting. The flight members would then use the radio to verify their sorts.[149] Dvorchak noted that the targeting and sorting process for a four-ship of F-15s could take upwards of 100 separate inter-flight radio calls. Even then, out of the roughly 140 four-against-four missions flown during ACEVAL, there was never a single instance where all the flight members sorted perfectly.[150]

Part of the problem was that for decades, fighter pilots were taught to shun the radio. As the previous chapters illustrated, there had never been a shortage of excess radio chatter since its first use in combat during World War II, but the fighter pilots had often preached that the solution was for everyone but the flight leader to simply shut up. For example, it was still a common maxim in the Eagle that the only time a wingman should key the microphone was to call: "Two"; "Mayday"; "Bingo" [running low on fuel]; or, "Lead, you're on fire."[151] But now with sorting tactics, everybody had to talk on the radio, and all nearly at the same critical time.

Despite the difficulties, the pilots after the test declared that the "name of the game is sorting. If you sort, you win." The test results agreed: on the occasions when all the Eagles locked on to a single target, "the *best* they ever did … was lose three [F-15s]…. When they locked on [to] three out of four [Aggressors], they kicked ass."[152] To facilitate correct sorting, a common fighter pilot vocabulary and a corresponding format and cadence were needed that would help maximize the flow of information. The Phantom pilots had laid the foundation with their intra-cockpit "descriptive commentary" and inter-flight "brevity comm," and there had been continuing development of the radio procedures since. For example, the 1st TFW's *Aerial Attack Manual* included nearly 50 percent more "brevity comm" terms in its glossary as compared to the instruction manuals used by the Phantom aircrews a decade earlier.[153] But, the cumbersome and prolific radio exchanges from ACEVAL showed that there was still much work to be done. There was simply too little

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[149] Cliver, interview; Wallace, interview.

[150] Dvorchak, interview.

[151] Jumper, "Instincts of the Fighter Pilot," 5. The four standard wingman radio calls remained a common wisecrack even after the wingmen started assuming greater offensive roles. See, for example, Winters, "Two, Bingo, May-Day..."

[152] Cliver, interview; Dvorchak, interview; and Sparks, interview; Sokol, interview.

[153] *1 TFW Aerial Attack Manual, Vol. 1*, iv–viii; *4453d CCTW RTU Weapons School: Intercept Techniques*, 4–9.

time during a fast-moving intercept for each pilot in a four-ship to fumble with their words, monopolizing precious radio time with imprecise musings such as, "I got the one to the left of the blip, which is right over the top of whatever it is...."[154] The concept of radio discipline therefore underwent a fundamental transformation, from simply not saying anything to saying everything simply and precisely.

In addition to refining their communications practices, the Eagle pilots also recognized the need for a simple and universal targeting plan that could be discussed in a pre-mission brief and then executed in the air with minimum radio communications. The pilots had worked on developing such a plan in the build-up to ACEVAL, but it was usually quickly dismantled by the Aggressors' unconventional tactics. "The formations we saw," explained Jeff Cliver, one of the Eagle pilots during the test, "were so diverse and exotic.... We had a general sort plan, if we saw a four-ship. But we hardly ever saw a good ol' four-ship; somebody's always 'rope-a-doping' or dragging [turning around] or doing something."[155]

Nevertheless, against a more conventional opponent, the ACEVAL pilots believed that a standardized targeting plan would prove helpful. Serving as the chief instructor for F-15 intercept procedures at the Weapons School following ACEVAL, Sokol was responsible for codifying and disseminating the new targeting plan to the growing Eagle community. When drafting his new intercept manual, Sokol spent hours drawing "little squares" that represented the target bricks on an Eagle's VSD, identifying which flight member was responsible for which radar target in a variety of intercept situations. After clearing the new text with the officials at TAC, Sokol forwarded the manual to the Eagle units at Langley and

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[154] Sparks, interview; Sokol, interview; Anderegg, interview, October 2, 2013; Cliver, interview; Welch, interview, July 10, 2012. Sokol noted that the Israeli Air Force played a role in the F-15 pilots' decision to abandon the "silence is golden" attitude. One of the AIMVAL-ACEVAL pilots participated in a brief exchange tour with the Israelis, and when he returned, he brought the surprise news: "Those guys are communicating all the time.... They're talking all the time." So, Sokol noted, "we started talking more amongst ourselves." Anderegg suggested that the "evolution of the brevity code was as important as any evolution in tactics, any evolution in formation, and evolution in weaponry as [the Air Force has] had." It is important to note, however, that a better method to assign and accomplish targeting besides radio communications would be to develop an inter-aircraft datalink. Datalinked fighter aircraft didn't appear in the Air Force for several decades after ACEVAL, though; the initial emphasis within TAC was on developing jam-resistant, frequency-hopping radios. On the continued emphasis of "brevity comm" seven-years after AIMVAL-ACEVAL, see Ross, "Comm Discipline."

[155] Cliver, interview; Sokol, interview. Sokol noted that there were inklings of rudimentary radar sorting tactics being developed at Luke AFB in the F-15 training units, but nothing as rigorous as what emerged during AIMVAL-ACEVAL.

other locations.[156] "Lead [takes] left, low, lead" quickly became the prevailing targeting mnemonic in the Eagle community, indicating that the flight leader was responsible for the target on the left if there were two side-by-side, the low target if they were flying at different altitudes, or the lead target if they were flying in trail; the wingman was responsible for the opposite target.[157]

Despite the new emphasis on communications and standardized targeting plans, there was still ample opportunity for miscommunication and confusion. For example, what if the two radar targets were not strictly side-by-side? The flight lead might interpret the enemy presentation as two targets in range and lock the lead target on the right side. But, if the wingman thought the enemy presentation still looked like a side-by-side formation, then he too would lock the target on the right, and the two Eagles would find themselves double-targeted. Additionally, although much better than the earlier radar in the Phantom, the Eagle's PD radar still occasionally generated false targets that appeared real, even in radar track. Cliver explained, "The loneliest feeling in the world is … staring through the [TD] box at nothing." And then there was always the urge that every pilot experienced during a confusing intercept to just lock something and start shooting.[158]

Thus, although they generally enhanced the pilots' chances at success and survival, the new coordinated radar tactics represented a substantially more complex employment scheme. Miscommunication of the desired targeting plan from the flight leader, hiccups in individual aircraft radar performance, pilot errors selecting and prosecuting an attack against his assigned target, and persistent missile failures all could render the new tactics ineffective. The additional complexity, however, also introduced flexibility and resiliency into the Eagles' employment schemes, since there were usually early opportunities to recognize and recover from these a deteriorating situation. Consequently, while a kill (or simulated kill) remained the ultimate validation, the single measure no longer adequately captured the performance of

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[156] Sokol, interview; Lamb, "Aerial Attack." The first F-15 Weapons School class arrived just after ACEVAL. Sokol noted that the topic of targeting frequently came up in repeated discussions around the bar at the Nellis Officer's Club, a historic clearinghouse for air tactics as F-15 pilots rotated in for training or Red Flag exercises. Additionally, Sokol taught the Aggressor pilots the Eagles' intercept and targeting plans (after AIMVAL-ACEVAL) so that when they travelled to unit locations to provide dissimilar air combat training, they could help spread the word on the on the new, preferred targeting tactics.

[157] Anderegg, *Sierra Hotel*, 160. Similar targeting schemes were developed for a variety of other potentialities, such as two F-15s facing more than two adversaries and four F-15s facing one, two, three, four, or five adversaries.

[158] Cliver, interview; Sokol, interview; Wallace, interview.

the various components of the human-machine system, both within the individual aircraft and among the aircraft in the formation. New intermediate metrics and new tools to evaluate them were needed.

New Ways to Measure Performance

The myth of the aerial victory achieved through singular, individual flying prowess had always been based on half-truths. In the days of the Sabres battling in MiG Alley, it was the wingman that played a critical but often unacknowledged role, freeing the flight leader to focus all of his attention on aligning his aircraft behind his target and squeezing the trigger. A decade later in the Phantom, it was the addition of the GIB and the new guided missiles that, along with the wingmen, were typically overshadowed by the glory of the individual pilot. Now in the Eagle, the wingman had gained new prominence and the GIB had been eliminated, but there were still several links that needed to be successfully closed if the pilots were to achieve victory with their favored long-range, radar-sorting tactics.

First, the flight leader needed to develop a targeting plan and communicate it to the flight members, who in turn all had to understand it. Second, each pilot then needed to manipulate his individual radar to accomplish the assigned targeting. Third, missiles had to be launched by the pilots at the appropriate times and under the appropriate conditions. And fourth, the missiles then had to work, still never a guaranteed prospect. The F-15's HUD camera, although considered a remarkable improvement over previous gun cameras because it also captured the weapons symbology displayed in the HUD, could at best only document the third step of the process—launching missiles in parameters—and occasionally parts of the fourth—if the missiles actually worked and the pilot was within range to film the ensuing fireball. But, the limited segments of HUD film showing weapons parameters at launch did not necessarily verify that the pilot was shooting at his assigned radar target, and as ACEVAL had demonstrated, simply lobbing missiles against any enemy target, even if they resulted in a fireball, was not always effective.

Two other recording systems helped supply critical, missing elements of mission data. The first was the portable cassette recorders that the Eagle pilots, like their F-4 predecessors, carried into their aircraft. The audio tape of the radio communications was particularly useful whenever there was confusion regarding the flight leader's targeting direction or when the flight members' attempted to verify their different radar sorts. The

second recording system was ACMI. Like in AIMVAL-ACEVAL, ACMI provided a windfall of information useful in the post-mission debrief. By revealing the positions of all the adversary aircraft in relation to the Eagles, the appropriateness of the flight leader's initial targeting directions could be assessed. Additionally, watching the ACMI playback of the mission allowed the pilots to understand the various aircraft maneuvers that were otherwise obscured once the Eagle pilots took their final locks and launched their Sparrow missiles. Finally, ACMI helped the pilots judge the effectiveness of their missile shots. But two significant limitations remained. First, only a small fraction of F-15 training engagements were flown over an ACMI range; and second, even when using ACMI, there was no means to assess the vital second step in the targeting process—the individual pilot's manipulation of his radar according to the information he had on his VSD.[159]

If the Eagle's radar always worked perfectly and automatically, then there would have been little reason to focus attention on this remaining intermediate step. The simple proof of a successful shot against his assigned target would have been sufficient testimony to a pilot's skill, and, conversely, a lack of a valid missile shot against the target demonstrative of his lack thereof. But, every pilot knew that the F-15 radar was never perfect, and that launching a missile against the correct target entailed more than simply pushing a button. Moreover, AIMVAL-ACEVAL revealed that different techniques for using the radar yielded substantially different outcomes, even when locking the correct sort. For example, Cliver earned a reputation during ACEVAL for being the first pilot to generally get a radar contact but the last pilot to ever get a radar lock. He also on average had the shortest time from when he took his lock to when he fired his first missile. It proved to be a recipe for success; Cliver was one of the most lethal Eagle pilots in the test. In contrast, the worst performing Eagle pilot was on average the last to get a radar contact, first to go into radar track, and took the longest time in track before firing his missile. The correlation, apparent only after the ACEVAL data were analyzed, was later associated with the rapid decline in a pilot's situational awareness once he entered radar track on a single target.[160] This realization led the

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[159] Sokol, interview. Sokol noted that even in the F-15 Weapons School course, it was difficult to gain access to the ACMI range at Nellis due to other, higher priority flight activities and tests.

[160] Sparks, interview; Dvorchak, interview; Cliver, interview. Cliver explained his rationale: "Find the rest of the guys. Find the rest of the guys.... That's why we begged for search while track or some TWS kind of a capability in the jet."

pilots to develop additional tactical standards that dictated when they should lock a target and when they should shoot their missiles.

During AIMVAL-ACEVAL, the specially instrumented test F-15s were equipped with systems that could monitor all of the pilots' radar actuations, plus two separate video cassette recorders that continuously captured the displays on the HUD *and* VSD.[161] Access to this extra data had facilitated the more detailed understanding of the effects of single target track and allowed the AIMVAL-ACEVAL pilots to learn the idiosyncrasies of radar employment. The pilots in the operational units, however, didn't have an ability to capture the same data. Instead, they continued to rely on hazy memories of what they might have seen or didn't see on their VSDs. Sokol alluded to the frequent frustrations encountered when trying to reconstruct an engagement without the necessary data:

> Flight Leader: "We had two guys on this guy, nobody on that guy. How'd that work? How'd that happen?"
> Number 2: "You know, I was looking into the sun. Couldn't see my leader."
> Number 4: "I locked on to somebody."
> Number 3: "I was focused on something else other than this, and just didn't have time to sit there with my head down in the scope."[162]

Now focused on coordinated radar tactics and longer-range missile attacks, the Eagle pilots begged for VSD video recorders for their aircraft, an item originally judged an unnecessary extravagance in a fighter designed for close-range air combat. They eventually succeeded in convincing TAC to fund the upgrade, but it took several more years before the units received them.[163] Once installed, the new VSD recorder became an essential tool for documenting and assessing pilot performance. Wallace explained that after his squadron began flying with the new recorders, his flight leaders could finally "really tell what the guy's doing … on [the] radar. If he's spinning the el-wheel from one extreme to another and not

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[161] Wallace, interview; Sokol, interview.

[162] Sokol, interview.

[163] Wallace, interview; Anderegg, interview, October 2, 2013. Anderegg recalled that the "big box VTR," housed in a compartment "under the engine intake," arrived in the new C-model of the F-15. "It ran 22-minutes.... We did have radar, and we did have HUD—couldn't have them together, one or the other. So at ten miles, there was a … 'Go HUD, go HUD' call" to remind the pilots to switch from recording the VSD to recording the HUD.

settling in and not taking time to search his area of responsibility, you can hammer [him] pretty good."[164]

Eventually, the F-15 community would begin to emphasize the *mechanics* of working the radar and the importance of being almost "robotic" when executing the search and targeting responsibilities. Pilots received specific, detailed instructions: set the altitude coverage to this; search for this many radar sweeps; then reset the altitude coverage to this; search there; lock only when the targets are inside of this range; adhere to the targeting plan.[165] Unlike in the radar-equipped Phantom, there was little room for individuality when it came to manipulating the Eagle's radar. There was a definite right way, and the pilots learned that they had better have a good explanation ready if they chose to deviate from the specified procedures when their radar tapes were watched in the mission debrief.

At first glance, the strict radar procedures and the emphasis on recording and reviewing them seemed to signal further deterioration of the once-prized individuality of the fighter pilot, a tenuous shift toward finally becoming the pushbutton missileman that the fighter pilots feared. But, upon closer inspection, the new automaticity in the Eagle that led to "robotic" radar mechanics and strict targeting contracts reflected the familiar pattern observed in the previous two chapters. The new radar equipment had not obviated the operator and his skills, rather merely redefined them. Thus, whereas in the Phantom it was an acknowledged art to get the radar to simply detect and display a target, in the Eagle that was accomplished by the radar automatically. Now the art resided in knowing what to do with the target that had appeared on the VSD.[166] Not surprisingly, this new skillset was not amenable to the old methods of documenting pilot performance, and the importance of the new VSD recorder, cockpit cassette recorder, and ACMI all reflected the shift. Additionally, the traditional methods of educating a young fighter pilot proved largely incongruent with the new skills required in the F-15. In the past, a pilot like Evans was simply thrown into the cockpit during "Clobber College" and told to follow his leader, he'd pick up the rest as he steadily accumulated more hours in the jet. In the Eagle, the same method of learning was

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[164] Wallace, interview.Wallace noted that "it would have helped out a whole lot more if we had the VCRs" when training the first, new F-15 pilots, "but we didn't."

[165] Like many other F-15 instructors, I told many a young wingman that I wanted them to be "robots" working their radar, adhering to the pre-briefed search and targeting plan. It was a phrase I had heard growing up as a wingman in the Eagle earlier.

[166] Welch, interview, October 1, 2013; Anderegg, interview, October 2, 2013.

no longer viable; a young F-15 pilot wasn't going to intuitively learn how to work the radar or get his sort just by spending more time in the air.

A New Fighter Pilot Experience?

"When I was flying an F-84, … I'd fly thirty hours a month, and maybe five to six hours of that was really demanding," Welch recalled. "Fast forward to the F-15; I'd fly twenty-five hours a month, and twenty-one hours of that was demanding." It wasn't the new jet itself. Welch, like countless other Eagle pilots, considered the F-15 an easy aircraft to fly.[167] Employing it was admittedly another matter, but that didn't necessarily mean that employing an F-84 in the mid-1950s was any easier, just different. Rather, Welch was alluding to the dramatic shift in the quality of training and instruction that coincided with the arrival of the F-15. In Welch's F-84, as in the F-86 and even the early F-4C, pilots had primarily developed their skills through repetition and self-evaluation. Moreover, simply accumulating flight hours had often helped cultivate proficiency, since the differentiation between a *flying* a fighter and *employing* one had not yet fully emerged. The same wasn't true in the F-15. An Eagle pilot was not going to develop his radar employment skills by simply flying a few extra, random sorties a month. And, despite now being college-educated, he wasn't likely going to be able to sift through the confusion of a radar intercept and identify his particular failures—human and/or machine—without specific, personalized, and reasoned instruction from a more experienced pilot. The symbiotic confluence of these three phenomena—more realistic training, college-educated pilots, and the recognition that self-education and simple repetition were no longer viable techniques to develop young fighter pilots—threatened to upend the traditional fighter pilot experience.

Historians such as Anderegg and Michel have previously called attention to the metamorphosis in Air Force fighter pilot training that emerged in the 1970s.[168] The new Aggressor squadrons and the large Red Flag exercises were two manifestations of the shift toward more "realistic training." In the past, the service's leaders tended to prioritize the preservation of their increasingly expensive aircraft over aircrew training. For example, Blesse complained that during the decade between Korea and Vietnam, "Safety became

[167] Welch, interview, October 1, 2013; Anderegg, interview, October 2, 2013. Welch explained, "The F-15 certainly didn't demand any more flying skill. In fact, it demands less." Anderegg affirmed the assessment: "The F-15 is the easiest airplane in the world to fly." See also Shower, "Foreword," 4.

[168] Anderegg, *Sierra Hotel*; Michel, "Revolt of the Majors."

more important than the tactics, more important than the gunnery, more important than anything. Safety was king. Safety took over." Pilots were prohibited from flying against different types of aircraft, and when they flew against their own type, they were often limited to specific, conservative flight regimes and maneuvers.[169] On other occasions, pilots were reduced to simply flying "around the flagpole" of their bases, successfully logging flight hours but practicing little else of consequence. After taking command of TAC in 1973, Dixon acknowledged that the service's focus had been misguided; the Air Force's fighter pilots had been sent to combat having practiced only "what amounted to calisthenics—[doing] the same thing every day in a very unreal atmosphere."[170]

The fighter pilots were not oblivious to the deficiencies in their training, but most did not appreciate how gross the failings were until after they landed in Vietnam. Emerging from their combat experience, the pilots felt betrayed by their service leaders that sent them and their squadron-mates to war unprepared, and often against borderline-worthless targets to boot.[171] In Michel's estimation, the frustration crystallized as a new "combat culture" within the fighter pilot community, which "emphasized flexibility, individual responsibility, little top-down control, and a 'get the job done' attitude that was entirely different from the strict supervision and emphasis on flying safety in the stateside Air Force."[172] Combat-seasoned "iron major" fighter pilots like "Moody" Suter represented this post-war fighter pilot ethos, and when they linked up with Dixon and his new emphasis on realistic training, the Red Flag and the Aggressor programs flourished, to the benefit of all Air Force fighter pilots.

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[169] Blesse, Corona Ace Oral History Interview, 62–65. Contrary to the "fuzzy thinks at TAC," Blesse argued that most fighter pilots understood the value of dissimilar air combat training, e.g. allowing an F-4 pilot to practice fighting against a Navy A-4. By focusing solely on similar combat training, Blesse explained, "the only measure of difference you have now is in the pilots themselves. If one guy cannot get away from another guy, cannot shake him off the rear by doing things that are normal [because the aircraft are the same], he will then try things that are abnormal and spin himself in." Thus, similar training was, in Blesse's estimation, "the most dangerous thing you can do." On the lifting of the restriction on dissimilar air combat training, see Johnston, "Dissimilar Aircraft Engagement."

[170] Quoted in Michel, "Revolt of the Majors," 186–88, 197, 219. Dixon also acknowledged the influence of the 1973 Arab-Israeli War on his decision to revamp the Air Force's air combat training programs.

[171] Anderegg, *Sierra Hotel*, 47–49; Michel, "Revolt of the Majors," 144. Michel cited Ron Keys's assessment, "I had been having the time of my life [up to this point] … it had never occurred to me I had been poorly trained." Keys eventually became commander of TAC in 2005.

[172] Michel, "Revolt of the Majors," 5. Worden suggested that the fighter pilots' new outlook contributed to their meteoric rise to the upper echelons of Air Force leadership, supplanting the traditional, SAC-minded bomber generals. Worden, *Rise of the Fighter Generals*.

Indeed, the story of Red Flag is often framed as the fighter pilots' innovative response to the trauma of air combat over Vietnam. But there was another component that also contributed to the new emphasis on "realistic training." For the first time in the history of the Air Force, the majority of its pilots held a college degree. And, as Anderegg noted, with that degree the pilots brought an "academic approach to problem solving" that historically had not been valued in fighter aviation. In the past, "when a guy had a problem doing something in an airplane," Anderegg explained, "he just did it over and over and over and over and over and over until he got it right."[173] It was the training method that Evans had encountered in "Clobber College." There were, after all, only a limited number of possibilities, and the outcomes of each trial, whether following a flight lead through a series of maneuvers or shooting machine guns at a towed target, were usually readily observable by the pilot. Moreover, with fighter pilots still regarded as the elite of naturally gifted aviators, it was understood that a pilot with the requisite skills would eventually find the solution; those that didn't were obviously not in the proper career and were best left behind.[174]

The shift to college-educated Air Force pilots had begun in the mid-1950s after the Korean War when the service began curtailing its Aviation Cadet and Officer Candidate School programs. Both commissioning programs had historically provided a means for those without college degrees to earn their lieutenant's bars and a chance at a set of pilot's wings. While it would make sense that the growing sophistication of the service's aircraft, missiles, and similar technological equipment in the 1950s and '60s had contributed to the sudden demand for college-educated officers, in actuality, the personnel shift was rooted primarily "in the context of officership" and the service's desire for broadly educated leaders conversant in topics like internal relations and business administration. Moreover, there was still a common perception in the service that "a college education had little effect on one's ability as a pilot" because *that* career "was based on gross motor skill development and hand-eye coordination."[175] Indeed, several former aces questioned the Air Force's new college-graduate requirement of its pilots.[176]

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[173] Anderegg, *Sierra Hotel*, 42; Anderegg, interview, October 2, 2013.

[174] The Air Force's traditional training method could be likened to cultivating a mathematics savant by having him practice only arithmetic and then offering him a complex slide rule as he walked into an examination covering differential equations.

[175] Mitchell, *Air Force Officers*, 197–99, 201; Anderegg, *Sierra Hotel*, 39–42. Mitchell noted that the nation-wide push for scientists and engineers following *Sputnik* "dovetailed nicely" with the Air Force's officer-education

There was significant value in the pilots' college education, though, regardless of whether it was in chemistry, electrical engineering, or history. For starters, the "academic approach" helped the fighter pilots rationalize the need for the realistic training programs that they desired following Vietnam. Then, once thrust into the melee of their Red Flag exercises, the pilots' college-cultivated "critical thinking" and "deductive reasoning" skills proved invaluable as they struggled to analyze and dissect the complex engagements. In the process, the pilots quickly realized that the massive simulated wars were not amenable to the simple trial-and-error and "brute force" methods of learning commonly used in the past.[177] Scheduling constraints represented one profound limitation, since the more realistic missions also tended to be larger affairs. Welch noted that an imperative consequently emerged to ensure that "every sortie" was "productive."[178] Complicating matters was the fact that while the results of air combat could still be determined based on the final tally of kills, the link between kill ratios and an individual pilot's actions within his cockpit had become much more opaque. Maximizing learning from each sortie therefore entailed tracing the oft-obscured causal relationships that contributed to mission success or failure.

The pilots could have been left to conduct their informal analyses and derive the appropriate lessons on their own, as they had been in the past. However, the combination of more demanding training, technologically sophisticated aircraft and weaponry, and analytically minded pilots led to a profound realization: senior pilots could no longer simply wait for their young wingman to figure out air combat on their own. At least in the Sabre

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plans. Both the Aviation Cadet Program and the Officer Candidate School continued operations for at least another decade. Officer Candidate School (OCS) was different than Officer Training School (OTS); the latter selected only college-graduates and continues to operate today. The other commissioning sources included the new Air Force Academy (established in 1954) and Reserve Officer Training Corps (ROTC) programs on civilian college campuses across the country. Officers that had entered the service without a college-degree were often offered the opportunity to pursue one, but the dramatic shift toward college-educated pilots occurred when the majority of World War II and Korean War officers retired or separated from the service.

[176] For example, see Rogers, Corona Ace Oral History Interview, 47. General Felix Rogers, himself a product of the Aviation Cadet program who went on to become a World War II ace and, after earning a college degree sponsored by the Air Force, commander of Air University and Air Force Logistics Command, exclaimed in a 1977 interview, "Everybody has got to be a college graduate to fly an airplane. Merde! I don't give a damn what the Human Resources Lab says---everybody doesn't have to be a college graduate to fly an airplane."

[177] Anderegg, interview, October 2, 2013. As fighter aviation became more technically focused, there was an advantage to possessing a technical degree, but the service never excluded officers with non-technical degrees from its ranks of pilots. A common joke among fighter pilots was their need to explain certain topics in simple terms for the history and political science majors in the ranks. See, for example, Snodgrass and New, "BFM for History Majors." BFM refers to basic fighter maneuvers, a.k.a. dogfighting.

[178] Welch, interview, October 1, 2013.

and the Phantom, the flight leader could easily look over his shoulder and quickly assess his wingman's performance. If the wingman was still in the welded wing position, all was well; if he wasn't, then the flight leader could quickly adjust his own tactics while simultaneously providing instantaneous verbal feedback to the wayward young pilot. In the F-15, and especially when practicing the long-range, radar sorting operations christened by AIMVAL-ACEVAL, the same visual feedback regarding the wingman's performance was not readily available. As Sokol noted, only half-joking, "You got Lieutenant [So-and-so] out there in Number 4, he may have forgotten to turn on the radar."[179] Recognizing that a young wingman who didn't know how to use his radar properly or that couldn't find his assigned sort was a liability to everyone in the formation, regardless of their own individual skill, the experienced flight leaders suddenly had a strong, self-preservation motive to get their young wingmen up to speed as fast as possible.

Thus, rather than simply being a rite of passage as in the past, the wingman position became more of an apprenticeship program conducted under the watchful tutelage of a more experienced flight leader. Gone were the days of simply showing up at the duty desk, filling out a mission card, and walking out the door to the jets in order to prove who was best. Instead, detailed pre-mission briefs were given, in which radar responsibilities were outlined and targeting plans and radio communications procedures reviewed. Even more significant, though, was the new emphasis on instruction and feedback on the sortie's particulars after the pilots had landed.[180] "Suddenly, the debriefings got very, very brutal,"

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[179] Sokol, interview. Typical of the past training methods, Sokol also described one pre-mission briefing during his F-4 front seater training program: "Our whole briefing was at the duty desk.... [The instructor] said, 'Have you seen the high-speed yo-yo?' ... 'Have you seen the low-speed yo-yo?' ... 'Have you seen the barrel roll attack?' ... 'Have you seen the butterfly setup?' ... 'We're going to do butterfly setups. Any questions?' 'No, sir.'" The "duty desk" is a dispatch desk in the squadron where pilots learn which specific aircraft they will fly for their mission.

[180] Anderegg, *Sierra Hotel*, 50–57; Keith, "Introduction"; Jumper, "Air-to-Air Training to Win"; Sokol, interview. Anderegg noted that the shift toward instructional briefs and debriefs began at the Air Force's Weapons School in 1974 and culminated with a set of articles published in the Winter 1976 and Spring 1977 issues of *Fighter Weapons Review*. Prior to that time, the Weapons School course was seen as "nothing more than a rite of passage wherein the students were harassed and hazed rather than instructed"—similar to the classic wingman experience in the operational units. It was this Weapons School attitude that had partly been responsible for the resistance to non-fighting wing formations in the Phantom. After the shift, however, the Weapons School instructors announced their new mission to "improve local training [across the Air Force] and make ourselves more efficient." One component was a "building block approach" to teaching pilots about air combat. Sokol commented on the shift based on his time teaching F-15 pilots at the Weapons School: "We're trying to teach the guys how to brief and debrief as much as anything else. I mean, flying the airplane is important. But that whole being an IP's IP [Instructor Pilot's Instructor Pilot], that was what we were about.... It's not to go out and just prove you beat some guy who wasn't somebody."

Welch recalled. "We went from, you're really kind of careful [criticizing] your flight, to no, we're going to talk about what you did wrong, to no, it's going to be the whole truth. And it's going to be brutal. And you're going to do better on your next mission or the next time you're going to hear about why in the hell didn't you fix that." Simply converting JP-4 jet fuel to noise was no longer acceptable; flight leaders and wingmen had to train *together* on every mission, with unprecedented intensity.[181]

Anderegg noted that within the context of the more demanding flight instruction and debriefs, pilots began directing the same "discipline, ... motivation, ... [and] intellectual curiosity" toward their ground studies, something that had also been historically lacking.[182] Granted, a pilot didn't need to know how to build his radar and his missiles, or the scientific theory and mathematical calculations that made them work, but he did need to become a veritable expert in their operation and employment. The Eagle pilot realized that he couldn't always wait for the CC-computed displays to appear in the HUD or VSD, and he therefore learned to anticipate the eventual computer output just as he learned to anticipate which radar mode he should select with his HOTAS during a dogfight. Pilots simply didn't have time to think through the complex "decision matrix" that confronted them during an air-to-air intercept. "You have to have already studied that," Anderegg explained. "You have to already know the intricate working details and the interrelationships of all those systems before you ever put the engine in afterburner and raise the landing gear.... The days of throwing your scarf around your neck, ... and pulling your goggles over your eyes, and pointing over the side and saying, 'Let's go after them, boys!', those days are gone."[183]

The effects of the new training scenarios, analytic thinking, detailed instruction, and additional book study were profound. Since the earliest days of military aviation, fighter

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[181] Welch, interview, October 1, 2013.

[182] Anderegg, *Sierra Hotel*, 74–76; Michel, "Revolt of the Majors," 146–48. In 1972, Phantom pilots and WSOs in TAC were tested on knowledge of their aircraft and its weapons systems. "The average score was about 40 percent, and only about 10 percent of the crews had passed the test."

[183] Anderegg, interview, October 2, 2013; Stucky, "Blocking & Tackling." Anderegg explained that it became obvious in the air which pilots had not yet come to this realization, the ones that preferred to spend their time "hanging around the duty desk, drinking coffee" instead of studying. "When you're out there flying with a guy that confronts a situation he hasn't thought about, you can tell it immediately. Because nothing happens. It's quiet on the radio. Airplane's just going straight ahead. You know that this guy—he hasn't seen this before, and he doesn't know what to do about it." Stucky made explicit reference to the fundamental importance of radar employment in the Eagle, likening it to "blocking and tackling" foundations in football. "The bottom line," he wrote, "is that radar skills directly contribute to your [situational awareness], and proficiency directly affects how well you can process that information into sound tactical decisions."

pilots usually thought they could identify who among them was the best and the most likely to become a future ace. It showed every time they flew, and there was often a wide gulf that separated the top pilots from the rest of the pack. Welch noted that in his two years as the Wing commander at Langley flying the first operational Eagles, that gap had effectively disappeared. While acknowledging that there were probably some "air-to-air guys who were held up as better than others," Welch felt that pilot performance in the F-15 was remarkably consistent, as opposed to that encountered in previous fighters. Thus, it became very difficult for him to distinguish his Eagle pilots based on simulated weapons employment alone. The F-15, in his words, had become "a great equalizer." Wallace agreed with the assessment, and he described his own difficulty trying "to identify who was good and bad in a tactical aspect.... There wasn't enough definitive that I saw [where] you could really say, 'OK, this guy's a top gun.' Everybody was a top gun."[184]

Hence, the post-AIMVAL-ACEVAL experience of the Eagle pilots had the potential to finally shatter the myth of the fighter pilot. As Blesse had predicted based on his brief observation of AIMVAL, with almost every pilot now regarded as a "top gun," the technology of radars and longer-range missiles seemed to have finally supplanted the pilot's traditional stick-and-rudder skills. Related, the new training and instructional methods seemed to indicate that the top fighter pilots were also no longer restricted to those who had been blessed at birth with "good hands." Simply put, pilots realized that between their remarkable technologies and more appropriate flight training, good fighter pilots could be made, not just found.

But, there were also some consistencies with the still-popular myth. The air-to-air kill remained an intense, individual affair. It was, after all, only a single pilot's press of the pickle button or squeeze of the trigger that could bring down another aircraft in aerial combat. It just so happened that in the Eagle, it was now accepted that that individual pilot could be either a flight leader or a wingman. Additionally, even after the shift in emphasis from close-range dogfights to longer-range intercepts, many pilots viewed the Eagle's gun as a powerful indicator of their vital role in the cockpit. One such pilot was retired Brigadier General Robinson Risner, a decorated Sabre ace from Korea, an F-105 pilot and eventual POW in

[184] Welch, interview, October 1, 2013; Welch, Oral History Interview, 80–81; Wallace, interview. Absent any remarkable buffoonery from a pilot such as getting lost, Wallace's judgment often came down to, "Were they part of the engagement or were they kind of just tagging along?"

Vietnam, and initially the Air Force's top officer overseeing preparations for AIMVAL-ACEVAL until he retired in late summer 1976. Risner explained in an interview, "It is still the human being that makes the airplane perform.... If it is an air-to-air fight, you fire your missiles; you try to kill him off at long-range, and when some get through, you bring him under fire with your Gatling gun. That requires pilot ability. There is no technological thing that you can use to get behind that airplane. It is pure intuition and training."[185]

Eventually, the Eagle pilots stopped justifying their indispensability based on the prospect of using the jet's 20-mm cannon during combat. There were plenty of other times when their distinctly human capabilities proved essential to the proper operation of the F-15. It didn't matter whether it was dogfighting with the gun or working the radar and shooting missiles, pilot aggressiveness and tenacity, when properly coupled to the capabilities of the aircraft, remained vital to mission success. Even Risner, although continuing to accentuate the close-range dogfight as the ultimate test of the pilot's skill, alluded to the necessary symbiosis between human and machine that extended across all combat regimes, "You still have the requirement of pilot capability, just pure old pilot capability, hooked to the technological capabilities of the aircraft."[186] Welch offered a similar appraisal. The new technologies and more focused instruction might have helped normalize pilots' employment of their weapons, but they had not obviated the role of heroic pilot in the air. For Welch, "the real distinction" in the Eagle "had to do with ... whether or not you seemed to have the leadership and the savvy to lead a flight to a successful mission."

Anderegg offered a glimpse into what that would entail in the coming years after AIMVAL-ACEVAL: "When you're leading a flight of four F-15s at 35,000 feet, supersonic, closing on ten adversaries, ... [and] you're managing [your] radar, [and] you're managing the radar of your three other fight mates, [and] you're managing your radar warning receiver, [and the] warning indications from your other three flightmates, and you're able to employ just on your airplane two or three very different kinds of missile systems, you need to have your shit together before the fight starts."[187] But then again, every other successful pilot,

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[185] Risner, Oral History Interview, 161–62; Martin, "Robinson Risner"; "Brigadier General Robinson Risner"; Hildreth, Oral History Interview. As the vice commander of the USAF Tactical Fighter Weapons Center at Nellis AFB, Risner was the Deputy Test Director for AIMVAL-ACEVAL. After Risner's retirement, Hildreth assumed the post and the deputy director responsibilities.

[186] Risner, Oral History Interview, 161; Welch, interview, October 1, 2013.

[187] Anderegg, interview, October 2, 2013.

whether they were flying a Sabre, a Phantom, or an Eagle, needed to have their "shit together" too; it just amounted to different "shit."

Conclusion

Although the F-15 Eagle would become known as the "world's most successful jet fighter" primarily based on its performance in long-range air combat, when it was first envisioned, the new twin-engine, twin-tail fighter was intended to be a classic dogfighter; a proper heir to the storied F-86 of MiG Alley fame.[188] It would be highly maneuverable. It would focus solely on air-to-air combat. It would be armed with a gun. And, it would have only a single seat. It represented not only everything that the F-86 was, but also everything that the F-4 Phantom wasn't; except, of course, for one critical element. Like the Phantom, the Eagle would carry guided air-to-air missiles and possess a radar to support them. Neither the Phantom's radar nor its missiles had earned a stellar reputation in the early days of air combat over Vietnam, but the need for them represented one of the key lessons the Sabre pilots had learned while battling MiG-15s near the Yalu River. There were obvious advantages to decoupling the performance of the aircraft from that of its pilots and its weapons, and guided missiles introduced redundancy and flexibility of design into fighter aviation previously unavailable with the machine gun-only-armed Sabres. Therefore, the Eagle, rather than being a direct retort to the Phantom, was in reality more like a hybrid.

It took time for many to come to this realization. Several, including the TAC commander Momyer, had questioned why a dogfighter in the image of the Sabre would need such complex and costly avionics. The criticisms sent those working on the F-15 program scurrying to justify the requirement for the radar. Their supporting arguments generally refrained from emphasizing the potential value of guided missiles in favor of the advantages the radar provided to the pilot as he maneuvered for the eventual close-range dogfight. Once the need for the radar was acknowledged, then it was obvious, they claimed, that the radar had to be a new, advanced PD-type, because only a radar that could effectively eliminate ground clutter was capable of being operated by a single pilot. Why only a single pilot? Cost, aircraft performance, the conflict experienced in the two-seat Phantom, and the simple fact

[188] Davies and Dildy, *F-15 Eagle Engaged.*

that air superiority had historically been accomplished by single-seat fighters were all proffered as answers.

When the Eagle finally rolled out from the assembly hangar at McDonnell Douglas in 1972, it was nearly double the size of the Sabre and "a good deal larger than the F-4."[189] It had a massive thirty-six-inch PD radar antenna buried in its nose, and pilots began to hear rumors that they would need to be "double-jointed" to operate its controls. Hoag told his fellow Air Force fighter pilots not to worry, "The entire air-to-air function is a simple, automatic process which frees the pilot to fly."[190] It was a pronouncement that the World War II and Korean fighter pilot veterans had heard many times before. And, like most instances when it had been uttered in the past, it proved to be false. But the statement's speciousness was not tied wholly to lingering engineering oversights in the weapons system's automation. Rather, it implied that the most demanding and important task a fighter pilot accomplished was the flying itself.

When the myth of the fighter pilot first emerged, stick-and-rudder flying had in fact consumed the majority of the pilot's attention as he struggled to stay aloft and alive. However, the demands on the pilot's flying skills since then had been steadily diminishing as the act of flying became merely a means to the eventual ends of aerial victory. By the time of the Sabre, flying skills still remained important, but flying the aircraft was not in and of itself especially challenging. The divergence widened with the Phantom and then eventually reached chasm-like proportions in the Eagle. Flying the F-15 was simple and brought exhilaration, but usually not glory. That was reserved for those who had mastered the Eagle's weapons systems, which even in the favored close-range dogfight environment demanded knowledge of auto acquisition radar modes, HUD symbology, and HOTAS functionality. The tasks of the fighter pilot had therefore outgrown their historical legacy and the classic denotations associated with the words *flying* and *pilot*. Yet, the public and pilots alike continued to focus on the means of fighter aviation instead of the end effects, buoyed by the notions of *pilots flying* that remained firmly embedded within the myth of the fighter pilot. The steady transformation of the fighter pilot's skills consequently went unrecognized.

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[189] Osterhout, Berdan, and Gordon, "F-15 Briefing Script," slide 4.

[190] Hoag, "Superfighter," 25, 28.

A confluence of factors that emerged coincident with the arrival of the Eagle helped expose some of the inconsistencies. There was a new focus on realistic training and a new emphasis by more analytically minded pilots on maximizing their and their flightmates' learning after every flight. Aiding their instructional efforts, the pilots had access to unprecedented mission documentation including the HUD film and occasional ACMI data. And then there was AIMVAL-ACEVAL, the year-long set of tests that by most accounts failed to accomplish their stated purpose, but proved invaluable in the process. As one of the test officials noted, every "good thing about ACEVAL and AIMVAL, either one of them, was by mistake. We learned a hell of a lot, because we didn't know the questions to ask when we went in."[191] The value of a new, longer-range, semi-autonomous and multi-targetable radar missile like the AMRAAM and new track-while-scan radar modes became clear in the skies north of Nellis AFB as the eight Eagle pilots tangled daily with the F-5E Aggressors. More important than the hardware, though, was the realization that against an anticipated Soviet threat armed with an all-aspect, fire-and-forget, IR-guided missile, an F-15 pilot that was simply looking to exploit his "good hands" and classic stick-and-rudder skills in a close-range dogfight was likely going to get himself killed pretty quickly. It wasn't the "best hands," but the "best head" that now defined a good fighter pilot in the Eagle.[192]

The F-15 had been labeled the "fighter pilot's fighter" when it was being developed as a dogfighter. But it had used a dated definition of *fighter pilot*, rooted in the myth, not the evolving reality, of fighter aviation. When the F-15 and its pilots underwent their remarkable transformation following AIMVAL-ACEVAL, the pilots were not reduced to the pushbutton missilemen they once feared. And because they were able to remain fighter pilots in their minds, their aircraft remained the "fighter pilot's fighter" too. Both just now possessed only the vaguest connection to the aircraft and flying knights of World War I fame. The democratization of fighter aviation, a goal since a group of young, Korean aces had argued on behalf of radar-ranged gunsights in 1952, had taken a significant step closer to realization with the Eagle and long-range air combat. While there would always be a place for natural flying talent in fighter aviation, the gates were now open to those individuals not

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[191] Cliver, interview; Dvorchak, interview; and Sparks, interview. Dvorchak agreed, declaring, "Everything that came out of [the tests] was a byproduct." Cliver offered another perspective on the tests' impact: "We made eight guys pretty proficient, as proficient as you could get. And God only knows how many lives and systems they touched as they proceeded on through their Air Force careers. So that's kind of cool."

[192] Anderegg, *Sierra Hotel*, 164; Anderegg, interview, October 2, 2013.

specially endowed with the attributes that had historically predetermined one's worthiness to become a fighter pilot. The Eagle leveled the playing field among the pilots. But, just as in the past, the new technologies and the democratization had not deskilled the pilot, only re-skilled him.

"Abby" Sveden's air combat engagement on January 19, 1991, during Desert Storm offers a profound example of the metamorphosis in fighter aviation that accompanied the post-AIMVAL-ACEVAL Eagle. With a radar and an AIM-7 missile, Sveden with only a few hundred hours experience in the F-15 was rendered as lethal as his Weapons School graduate flight lead, "Gunga" Dingee. Neither Dingee nor Sveden's element leader, Prather, had voiced a concern about the young wingman flying out in tactical formation, locking his assigned sort, or launching his missiles from miles away. He had done exactly as they had trained him, and he earned sole credit for his kill because of it.

Sveden's long-range kill was not reflective of the way the Eagle was originally supposed to have been employed. Granted, Sveden was flying a newer C-model of the Eagle that had been slightly modified based on the lessons of AIMVAL-ACEVAL, but the majority of the systems in the jet, including the HUD and HOTAS, retained the same architecture as when the jet was first optimized for employment in "close-in, highly maneuverable combat." In addition to the flexibility of the airframe and the technologies therein, the details of Sveden's kill also reveal the flexibility of the human operators as they adapted with their technological hardware.[193] Without the new formations, new training methods, and new coordinated radar tactics adopted following AIMVAL-ACEVAL, Sveden likely would not have earned his victory that January afternoon. The new tactics represented the pilots' best attempts to use their new machinery in an optimum fashion. They were also distinctly social phenomena that, although related to the arrival of the F-15, had not been predetermined when the engineers first drew up the Eagle's design. Sveden's kill therefore offers evidence of the inseparable human-and-machine dynamic in fighter aviation.

Cliver, specifically referencing the AIMVAL-ACEVAL experience but also alluding to fighter aviation more generally, explained, "That's what's beautiful about having people in

[193] Seamans, "Planning the Total-Force Concept," 71. Of note, the Eagle's flexibility was also revealed when the airframe was converted into the two-seat, air-to-ground-focused F-15E Strike Eagle.

airplanes. Guess what? You're going to figure out how best to use what you are provided."[194] His comment indicates an appreciation for the human-and-machine perspective, but it also conflates the operator's physical presence with the co-evolutionary process. A critical social element that had defined the Eagle's employment in the long-range environment—the flight leader's use of coordinated radar tactics to extend his control over the multiple radars in his formation—was one indication that physical presence was not in and of itself vital. That minor detail would be demonstrated in the coming decades when new technological developments pushed pilots out of the cockpit and into remote ground control stations.

[194] Cliver, interview.

Chapter 6

Conclusion:
"But Warriors Are Now But Operatives"

War shall yet be, and to the end;
But war-paint shows the streaks of weather;
War shall yet be, but warriors
Are now but operatives; War's made
Less grand than Peace,
And a singe runs through lace and feather.

—Herman Melville, "A Utilitarian View of the *Monitor's* Fight," *Battle-Pieces and Aspects of the War*, 1866

The Union Navy's USS *Monitor* of the American Civil War was a peculiar vessel. Part-iron raft, part-submarine, only the ship's conspicuous revolving turret, which shielded two eleven-inch Dahlgren guns behind nearly a foot of armor plating, extended much higher than the waterline. Not quite sure what to make of the curiosity, numerous American literary authors and poets of the period selected the *Monitor* as their subject. Many, including Herman Melville, chose to cast the iconic ironclad vessel as a harbinger of the coming age of industrial warfare, a time when mathematical calculations and "engineering skill" would replace the "passions" of the fighting men. According to Mindell, Melville's outlook was unique though, and his particular "Utilitarian View" the "richest," because Melville was able to capture the irony that others had often overlooked when they reflected on the *Monitor*. That irony did not escape the ship's Acting Assistant Paymaster, William Keeler, who, destined to serve in its dank but otherwise well-appointed and well-shielded officers' cabin, wrote his wife upon seeing his new vessel, "There is not danger enough to give us glory."[1]

[1] Mindell, *War, Technology, and Experience*, 2, 41–43, 85, 123–24, 131. Mindell noted that one other American author also noted the irony in the *Monitor*, Nathaniel Hawthrone, who wrote of the ship: "even heroism—so deadly a gripe is Science laying on our noble possibilities—will become a quality of very minor importance."

Glory would come to the crew of the *Monitor*, but not necessarily in the classic "war-paint" and "lace and feather" sense that marked previous naval heroics. After the *Monitor's* thundering four-hour fight-to-a-draw battle against the Confederate ironclad *Virginia* in the waters of Hampton Roads on March 9, 1862, the Union Navy and President Abraham Lincoln himself proved exceedingly reluctant to risk their prized ship in another battle. Thereafter relegated to riverine and blockade duty, Keeler complained of his ship being placed in a "glass case" and the crew being imprisoned "in the bowels of our iron monster." "The only fear I have," Keeler wrote, "is of getting eaten through by rust." Nevertheless, despite feeling that they were being cheated out of the opportunity to prove their valor at sea, Mindell observed that the *Monitor's* crew "experienced the full flush of military glory." It was, he noted, the "paradox of the war machine: political imperatives of developing, selling, and deploying a complex technology gave new life to the heroic aspect of war by promoting the *Monitor* and its crew, even as the machine's operations reduced their status from warriors to operatives."[2]

However, Mindell also emphasized that this transformation did not eliminate the opportunity for the *Monitor's* "operatives" to demonstrate their heroism. Indeed, the leaky, smoky ship nearly suffocated her crew during her first voyage out of New York harbor, and the ship's "basic lack of seaworthiness," which culminated in her loss in a gale on New Year's Eve, 1862, became well-known within the Navy. As Keeler noted in one letter, "anyone could fight behind impenetrable armor," but volunteering "to undertake the trip and go into the fight in an untried experiment" was itself worthy of "the credit, if any is due." Thus, while the members of the *Monitor* crew initially may have worried that their new mechanical curiosity would rob them of their role in warfare, Mindell argued that "a place for human skill, and hence for heroism," remained. It was a "*contingent* heroism" though, inextricably linked to the performance of their war machine and therefore "always in question and always in need of maintenance."[3]

Mindell hypothesized that the fighter pilots of the Great War might have much in common with Keeler and the crew of the *Monitor*. As with the Civil War sailors a half-century earlier, for the new aviator aces, "heroism increasingly meant mastering the machine

[2] Ibid., 88, 99, 109, 147–49.

[3] Ibid., 64–68, 113, 133, 149. Emphasis in original.

as much as destroying the enemy." Indeed, a pilot like Richthofen or Rickenbacker could not accomplish the latter without first developing the skills demanded by the former. And therein, Mindell suggested, lay some of the irony of the new flying combatant; even the acknowledged masters could never escape the "inherent danger of the machine." That uncomfortable reality was regularly reinforced whenever a pilot saw his friend's wings suddenly crumple or his engine erupt in flames. The aces' relationship with their aircraft therefore cut both ways, it could be "simultaneously protector and weapon, potential savior and potential tomb."[4]

The Irony of the Fighter Pilot

As this dissertation demonstrates, that irony did not suddenly disappear when the first military pilots returned home from the Western front. Nor was it solely restricted to the fighter pilot's prospect of sudden fame or gruesome death based on his machine's ability to withstand the rigors of air combat. Rather, an equally ironic and potentially more informative element centers on how the collective image of the fighter pilot and aerial heroism remained relatively static in the ensuing decades, despite the dramatic transformation in the skills required of the fighter pilot. Granted, from its outset the myth of the fighter pilot—an individual who marshaled an aggressive and tenacious spirit and superior stick-and-rudder flying skills to conquer opponents in valorous aerial battle—had always sacrificed historical "richness" and "contingency" in favor of its simpler, more symbolic representation. But, the divergence between that myth and the actual fighter pilot experience was exacerbated following the introduction of advanced fire control systems and their associated missile weapons after 1950. The new technologies threatened to replace the knightly, "warrior" image of the fighter pilot with that of a push-button missileman "operative." The editors at *Life* had surmised as much in early 1952.[5]

Reassessing the history of fighter aviation from a human-and-machine perspective allows us to move beyond the often captivating but one-dimensional "great machine" or "great pilot" narratives and instead develop a richer understanding of the more complex interactions that link the machine and the pilot. By constructing a cognitive history of the

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[4] Ibid., 146–47.

[5] "From Struts to Jets," 62–63.

fighter pilot, we can appreciate the evolving skills that defined a successful pilot over time, a transformation usually obscured by the popular myth that surrounds him. Additionally, in the case of the formations that the fighter pilots developed and employed, we can see how changing human-machine relationships affect critical interpersonal relationships and social conventions as well.

The formations used by fighter aircraft have long been viewed as products of objective, carefully balanced tactical necessity. This dissertation shows that tactical formations can also be seen as tools developed by the fighter pilots to help mediate their relationships with both their machinery and their fellow pilots. Hence, changes in weapons and the means of employing them had the potential to upset the social relationships propagated by particular formations. The first formations emerged in the Great War when fighter pilots realized that if they coordinated their actions, they could maximize their chances of collective survival and success. The soon-agreed upon convention placed the more senior pilots out in front of the formation, leading and concentrating primarily on offensive action. The junior pilots in contrast focused on defensive lookout. World War II reinforced this division of tasks. By the advent of jet combat in MiG Alley, the social conventions between formation leaders and wingmen established earlier in fabric-covered biplanes had been firmly ingrained within the American fighter pilot experience, to the point that the wingman's contributions to his leader's victories were often purposefully obscured. While there were still obvious tactical reasons for designating a "shooter" lead and "looker" wingman while battling MiGs over Korea—not the least of which was the speed at which a speck on the canopy could transform into a fireball-spewing MiG—the wingman experience had essentially become an institutionalized rite of passage for a young, budding fighter pilot in the US Air Force.

By the time of the F-4, the experience of being "blooded" as a wingman flying in "fighting wing" had essentially supplanted its tactical utility. Snuggled up close to his leader's aircraft, the wingman was unable to employ any of his missiles to support his flight leader when needed. Additionally, because the F-4 was much more powerful and maneuverable than previous fighters, the fighting wing position also compromised the wingman's ability to perform his defensive, lookout task, since he had to constantly focus his attention on following his leader's abrupt maneuvers. Some fighter pilots advocated for a change, but they encountered stiff resistance. They quickly learned that adjusting the tactical formation

to take better advantage of the F-4's missiles required not just a geometric shift in the wingman's position, but also a psychological one in the minds of the veteran fighter pilots. Moving the wingman to a more line-abreast position represented a more equitable partnership between the two aircraft. Senior flight leaders would no longer be able to devote the majority of their attention to offensive employment; they would now be as responsible for their wingman's survival as their wingman had historically been for theirs. Moreover, the newly proposed formations threatened the flight leader's historic prerogative of seizing the glory of aerial victory for himself. Despite potentially viable alternatives, the welded wing formation and the social hierarchy it represented remained largely unchanged during the Vietnam War.

There was obviously another significant interpersonal challenge that accompanied the F-4 into battle besides the fighting wing position: the second crewmember in the Phantom's cockpit. The introduction of a GIB dedicated to operating the Phantom's complex radar shattered the idyllic image of the fighter pilot as self-sufficient, lone eagle. The effect could be readily seen in the young, newly winged pilots' scorn for the Phantom. Despite the F-4's record-setting speed, few pilots wanted to spend years riding in the back seat of one staring at a radar screen. What they should have been doing, they thought, was what they had been trained to do: fly in the *only* seat of a proper fighter like the F-100 or F-105. Moreover, the disdain in the cockpit was often mutual. The front seaters, already reluctant to acknowledge their evolving partnership with somebody flying alongside them, were even more recalcitrant in acknowledging their dependence on somebody that had invaded the sanctity of their cockpit. The fact that the offending individual wore the same set of Air Force wings on their flightsuits only exacerbated the tension.

The F-15 Eagle, advertised as the "fighter pilot's fighter" and heir to the fabled Sabre, promised to revive the image of the single-seat fighter pilot and the cherished autonomy it represented. Since the Eagle wasn't expected to perform the majority of its combat at long range or in adverse weather, there was no need nor any desire for another GIB. However, after AIMVAL-ACEVAL revealed that the Eagle would need to forego its emphasis on close-range dogfighting in favor of longer-range air combat, the Eagle pilots had to make significant adjustments to their employment concepts. They already had discarded the fighting wing position of Korea and Vietnam in favor of a wider-spaced "tactical" formation, implicitly accepting the more equitable partnership between leader and

wingman that it represented. Then, to maximize the effectiveness of their PD radars and their missiles, the Eagle pilots developed new communication strategies that allowed them to seamlessly share information among all the flight members. The introduction of sorting tactics, which made little distinction between leader and wingman, signaled the end of the strict "lead-shooter, wingman-looker" responsibilities that had been so central to the historic fighter pilot experience. Moreover, when combined with the new imperative placed on realistic, combat-like training scenarios, the Eagle pilots realized that their traditional methods of learning through mere repetition and trial-and-error were no longer viable. Flight leads thereafter began devoting significant time and energy toward instructing their junior partners. In the process, the wingman experience was transformed from a rite of passage into an apprenticeship program pursued under the watchful eye of a more experienced and more interested master.

In addition to the shifting interpersonal relationships, intra-cockpit changes in tasks and responsibilities associated with the new equipment also altered the fighter pilots' experience of air combat and the skills required for success therein. As with the pilots' formations, the magnitude of these changes was not immediately apparent when the first A-1C(M)s began arriving in Korea. The new gunsight, the pilots were told, would automatically solve the challenging mathematical calculations that defined a successful gun attack. Thereafter, the pilot would simply need to maneuver to place a mechanically aimed pipper over the target before squeezing the trigger. But, the new gunsights failed to match the promise, a function of poor design, unreliable electronics, and faulty assumptions of air combat invoked when developing the system. As the pilots were apt to point out, the final aiming and squeezing of the trigger only accounted for 10 percent of the air combat problem, and the new A-1C(M) not only didn't help with the other 90 percent, it actually made its accomplishment all the more difficult. The heavy components of the radar and gunsight weighed down the Sabre, and the pilots struggled to interpret and monitor the performance of their oft-malfunctioning system. Moreover, the pilots still had to maneuver to a position essentially behind their target and within range of the same .50-caliber bullets that many of them had used years earlier in their P-51s and P-38s.

While the initial deployment of the A-1C(M) itself was a disappointment and did not appreciably alter the tasks of the fighter pilot, it signaled many of the changes that would come with new fighter armament and fire control systems. Most significantly, once the

Sabres' radars and gunsights had been restored to factory condition through Project Jaybird, the pilots realized that to use their radar-gunsight system effectively in air combat, they had to actually study and become knowledgeable in its operation. Today, the requirement seems commonsensical, but two preconceptions conspired against the pilots in Korea. First, for many pilots, it was their initial exposure to a fire control system that was advertised as being completely automatic. In fact, the engineers had earlier discouraged the pilots from developing their own intuitive understanding of the system for fear that they would deviate from the gunsight's direction. Second, fighter aviation was still seen as the province of naturally gifted aviators. To use the system effectively, the pilots therefore had to realize that while their flying intuition might still have gotten them airborne in a Sabre with only a bare minimum of training, the same natural abilities didn't automatically extend to their new fire control systems. At first disconcerting, this differentiation of skills was eventually embraced. Indeed, when the controversy erupted over the future of radar-ranged gunsights in fighter aircraft, a key argument in favor of the complex fire control systems was that they didn't rely on the same set of "birdman" skills or years of air combat experience that had characterized successful fighter pilots in the past. The new systems would, in effect, help democratize fighter aviation, opening it to individuals that possessed a broader range of innate flying acumen.

The F-4 Phantom with its all-missile ordnance embodied this democratization principle. The Navy-designed aircraft therefore constituted a significant threat to the classic tasks of the fighter pilot. For example, in the past, Sabre pilots employing machine guns needed to deftly manipulate the stick and rudder in their aircraft to maneuver into a position close to their adversary and near his six o'clock before opening fire; the closer and nearer, the better. Flying intuition would help the Sabre pilot get there, and then luck (or maybe an operable A-1C[M]) would help him bag his prey. In the Phantom, flying to that same position behind the adversary would eliminate *any* chance of aerial victory; the Phantom's Sparrow and Sidewinder missiles simply could not be employed from there. Rather, the F-4 pilot was supposed to leave the aggressive maneuvering to the missiles. The new arrangement, it was believed, would render fighter aviation simpler, at least from the perspective of the pilot.

The circumstances of the Vietnam War and the pilots' inability to employ their missiles from longer ranges upset the plan. Consequently, the F-4 pilots needed to continue

cultivating the flying skills that would allow them to dogfight a smaller, nimbler MiG while simultaneously developing a new intuition that would allow them to employ their missiles. Complicating matters, the new offensive position defined by the Phantom's missile ordnance was exceedingly complex, constantly morphing and shifting in size and shape based on the changing geometry between attacker and target. The Phantom pilot also had to become intimately familiar with the panoply of air-to-ground missions and their assorted munitions. The net result, in the words of Welch, was that the F-4 pilot was transformed into a "systems operator," responsible for managing not only his aircraft, but also his semi-autonomous missiles, air-to-ground weapons, and his radar (through his GIB intermediary).[6]

The single-seat, single-mission focus of the F-15 was designed to alleviate some of the systems-level responsibilities that had been levied on the Phantom pilots. Simply flying the Eagle was made easier with the introduction of a dual, hydromechanical and electronic CAS flight control system. Furthermore, there was neither a GIB to manage nor any air-to-ground munitions to worry about. While there would be a radar and Sparrow missiles aboard, the F-15's designers had taken great care optimizing the systems' employment for the Eagle's planned close-range battles. Consequently, fighter pilots were told that they would finally be able to exercise their flying intuition without distraction when employing their aircraft.

The promise, however, misrepresented the tasks of modern fighter aviation. It suggested that *flying* a fighter and *employing* one were still synonymous. They weren't. The tasks of operating the aircraft's complex equipment had surpassed the importance once ascribed to manipulating the aircraft's stick and rudders. The discrepancy between the two was further exacerbated by the experience of AIMVAL and ACEVAL and the subsequent emphasis on long-range radar employment in the F-15. While some of the Eagle pilot's tasks resembled those in the Phantom, others were vastly different. Of note, the fighter pilot in the Eagle no longer had to hunt for a particular "fuzzy blip" among a sea of "fuzzy blips." Instead, he worked with discreet target bricks that appeared on a synthetically generated, digital representation of a radar scope. Additionally, the individual intuition that had previously guided the Phantom pilot's employment of his missiles had now been programmed into the Eagle's high-speed, automatic CC to be calculated and then displayed

[6] Welch, interview, October 1, 2013.

in the HUD. These advancements certainly simplified some of the employment difficulties that had plagued the Phantom, and they in turn freed the Eagle pilot to develop a new set of skills. For example, no longer forced to concentrate on merely keeping his aircraft in the air and pointed in the right direction or coordinate with a GIB, the F-15 pilot was able to devote significant attention to processing all of the information now available to him on the HUD and VSD to plan his optimum missile attack. The ability to integrate this abstract information and then execute the proper action became the new mark of a skilled F-15 pilot.

Despite this remarkable thirty-year transformation in the tasks and social conventions within fighter aviation, fighter pilots maintained a powerful, romantic connection to their individual aircraft. The changing technologies had not fundamentally altered the oneness that was central to the fighter pilot experience since the Great War. It was present even in the Phantom. Reminiscent of Salter's description of the Sabre, Olds once described the sensation of climbing into his aircraft:

> Man merges with machine; he doesn't simply use it. You don't climb into an aircraft and sit down. You strap the machine to your butt, become one with it. Hydraulic fluid is your blood; titanium, steel, and aluminum, your bones; electrical currents, your nerves; the instruments, an extension of your senses; fuel, the food; engine, the power; the control surfaces, the muscle. You are the heart, yours is the will, yours the reasoning power. You are something more than earthbound man. You are augmented and expanded by the miracle of the machine. You are tied to it physically and you are part of it emotionally.[7]

In the Eagle, pilots now also had a powerful, PD radar to serve as their eyes and a myriad of HOTAS switches and buttons—new neural connections—that linked their brain with the CC-brain of the aircraft. The increased automation that had accompanied each successive generation of fighter aircraft had not, in the fighter pilots' opinion, subverted their autonomy, because in the end, the pilots' intuition and skill were never subsumed by the new equipment. The pilot was always needed to make the system work, to provide the "heart, … the will, … the reasoning power." It was a powerful testament to the importance of the "warrior" pilot that also validated a central element of the fighter pilot myth.

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[7] Olds, *Fighter Pilot*, 293. Olds's eloquent, romantic passage does not, in my opinion, match the tone of the rest of his memoirs; the attitudes, however, are consistent with his other accounts. On the Sabre pilot's similar personal connection, see Salter, *Hunters*, 193.

Within this context, some contended that the pilots' necessary, continued interactions with systems once touted as being completely automatic illustrated the limitations of automation within fighter aviation. Air combat, they suggested, was too dynamic and the decision matrices too complex to be programmed into either mechanical or electronic computers. Each recurring attempt to automate a fighter pilot's tasks—be it stadiametrically ranging a target, maneuvering into position to employ weapons, or manipulating and interpreting reflected radar energy—had never matched initial expectations and ultimately saddled the pilot with additional, complex tasks when he was forced to compensate for the automated systems' failings. Indeed, a common refrain of the "Reformers" and the self-proclaimed "fighter mafia" during the 1980s was that engineers and service leaders needed to stop burdening fighter pilots with these costly, complex, and failure-prone devices; the pilots should be left alone to do what they did best—fly.

The ironic thing is that while flying continued to distinguish the pilot as "something more than earthbound man," it was never as all-encompassing a task as the myth of the fighter pilot or its adherents suggested. Even from the dawn of military aviation in the First World War, the act of flying—manipulating the aircraft's stick and rudder to stay aloft—was recognized as but a means to the eventual end of aerial victory. Consequently, there were from the earliest days attempts to transfer some of the pilot's flying responsibilities to his machine. Fighter pilots longed for an aircraft that was stable enough in the air that they could shift their attention to scanning the sky or clearing a jammed machine gun without worrying that their aircraft would suddenly go out of control. But the pilots also wanted the ability to force their aircraft to the edge of its flying envelope when required, flinging it about during an attack or while defending themselves. To a certain extent, this division of tasks signified an initial attempt at automation. Thereafter, the fighter pilot's skill would increasingly be defined by his ability to rapidly allocate his attention, deciding when and how to intervene in order to exercise more direct command over his machinery.

The history of fighter aviation is therefore also a history of the struggle to understand automation in the broader sense. Only decades later would Sheridan and others help illuminate the various gradations within the term *automation* itself. Prior to then, designers, engineers, and operators struggled to articulate how their various fire control systems fit within the automation rubric. The initial design of the A-1C(M) represented automation applied in the strict sense. It granted the pilots little agency, effectively reducing

them to the role of mere "operative" and stoking the pilots' fears of being deskilled by future automated systems. But, within months of the new gunsight's introduction in combat, pilots and engineers realized that this strict separation of tasks between pilot and machine was inefficient. A more balanced and flexible approach was needed. In the case of the A-1C(M), the pilot was subsequently encouraged to understand and optimize the performance of his fire control system for particular situations, which he exercised based on new procedural and technical knowledge and novel control mechanisms such as Jenkins's range limiter. The shift in expectations was akin to recognizing the difference between "full automatic control" and "human supervisory control," a distinction later popularized by Sheridan.[8]

Lacking the specific *supervisory control* terminology, however, did not stop the development of fire control systems that embraced the concept. Thus, while many continued to advertise the benefits of automation in their advanced fire control systems, notably the systems' supposed ability to free the pilot to perform other essential flying tasks, there was a growing appreciation among engineers and pilots alike that the new systems also required their own set of critical tasks, and that these tasks could often only be performed by the human pilot seated in the cockpit. One of the great ironies within fighter aviation during the period 1950 to 1980 is that the systems the pilots once feared would push them *out* of the cockpit in fact became increasingly reliant on skilled pilots remaining *in* the cockpit. And, as long as they remained in the cockpit of fighter aircraft, the operators would continue to be known as fighter pilots. The airmen eventually realized this, and the anxiety they revealed in the pages of *Fighter Weapons Newsletter* in the 1950s (figure 1.3) soon subsided.

But, while the new fire control systems validated the pilot's necessary presence in the cockpit and therefore his place in the fighter pilot myth, the new equipment also dramatically transformed the skills required of him. For example, by the time of the F-15, the fighter pilot's flying intuition had been largely supplanted by radar intuition, and his skill at manipulating the control stick overcome by his skill operating the HOTAS. Moreover, these new fighter pilot skills were not readily transferable between aircraft. Whereas in the past a

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[8] Sheridan, *Telerobotics, Automation, and Human Supervisory Control*, 1. Sheridan noted that the term *supervisory control* "is derived from the close analogy between the supervisor's interaction with subordinate human staff members in a human organization and a person's interaction with 'intelligent' automated subsystems." More formally, "*supervisory control* means that one or more human operators are continually programming and receiving information from a computer that interconnects through artificial effectors and sensors to the controlled process or task environment."

pilot could transition from one aircraft to another with relative ease and often without formal training, it became increasingly difficult to do so in modern fighters. An F-15 pilot was as uncomfortable initially flying an F-4 as an F-4 pilot was trying to figure out an F-15's HOTAS.[9]

This unique pairing of specific pilot skill with particular aircraft was one manifestation of the evolving human-*and*-machine *system* within fighter aviation. It also pointed to the continued importance of the pilot's tacit knowledge, his "reasoning power" in Olds's poetic description. The introduction of highly complex, technologically advanced, and procedurally driven systems had not eliminated the requirement for hands-on expertise. Pilots may not have needed the same practical flying skills, but they still needed to be skilled. And, if they hoped to both supervise and operate their machinery during high stress aerial combat, the pilots concluded that those skills were best cultivated in a craftsman-like way, continually practicing and refining their ability to process data from a variety of sources to then inform their tactical decisions in combat scenarios.

Such an interpretation of *craftsmanship*, which I used throughout this dissertation, relies on a slight adaptation of Sennet's more conventional use of the term and his emphasis on the creation and manipulation of physical artifacts. The history of fighter aviation demonstrates that the principles of craftsmanship lauded by Sennett can be extended to cognitive and system supervision tasks. Just as the artisans' steps for crafting an exquisite piece of woodwork or jewelry cannot be easily captured and reproduced, the fighter pilots' evolving skills were not amenable to codification in flight manuals. Supervising systems and integrating information may not have conformed to the fighter pilot myth as the means by which heroic pilots instilled their "heart" and "will" into their aircraft, but it nonetheless more accurately reflected their role in the cockpit. Importantly, the pilots learned that this shift did not lessen or cheapen their fighter pilot experience; it was the same lesson learned by the sailors aboard the *Monitor* a century earlier.

Regrettably, the historical "richness" and "contingency" within fighter aviation is often obscured by the popular appeal of the fighter pilot myth. Developing a cognitive

[9] Sokol, interview. For example, Sokol remarked that he had a friend who, after only flying F-15s (beyond the normal pilot training aircraft), had an opportunity to fly the F-4 while attending the Air Force's Test Pilot School. The friend later told Sokol, "I don't know how you guys could go to war in that airplane, because it's just a full-time job to fly it, let alone do anything else with it." Sokol agreed, "And it was."

history of the pilot-operator grounded in Hutchins's methodology, striving to privilege neither human nor machine, allows us to move beyond the symbolic representation of the fighter pilot and develop a more complete understanding of what he actually accomplished and how he went about doing it. Only in partnership could the pilot and his machinery collectively perform the additional tasks air combat required of them. Viewing fighter aviation as a story of only "great pilots" or "great machines" fails to illuminate these important linkages. In contrast, the cognitive history approach facilitates viewing fighter aviation more holistically, as a complex, socio-technical system of humans *and* machines working together to accomplish a common end-state, but through evolving tasks and methods.

Although they continued to celebrate their skills as individuals, the pilots themselves began to indirectly acknowledge the value of this systemic approach when they demanded varied recording technologies and new techniques to evaluate their performance in the air. At first in the F-86, only a gun camera was required; the bullets flew straight and it was up to the pilot (with a little help from his gunsight) to maneuver his aircraft to aim them correctly. By the time of the F-4, a gun camera was wholly inadequate because the missiles had "minds" of their own; it was more important to capture the intra-cockpit conversations between the pilot and his GIB as well as the other radio communications. With the arrival of the F-15, a combination of ACMI, cockpit voice recorders, and video recorders for the HUD and VSD were needed to accurately assess the performance of the pilot based on his manipulation of the radar, his maneuvering of his aircraft, and the probabilistic performance of his missiles. This shift toward capturing and evaluating additional streams of data reflected the tighter coupling between pilots and their machines. Pilots soon realized that it was nearly impossible to disaggregate their performance from that of their equipment; the two were increasingly one and the same.

These circumstances and nuances, however, run counter to the timeless myth of specially endowed, naturally gifted fighter pilot. Divorced from this historical "contingency," an ahistoric interpretation of fighter aviation and its pilots has persisted. Even today, many fighter pilots neither understand nor appreciate the evolving nature of their tasks, their changing relationships with their technologies, nor the implications therein. The effects can be pernicious.

A Lesson for Future Automation

Although this study terminated with the F-15A, the push toward greater automation in fighter aviation did not abruptly end when the C-model version of the Eagle started rolling off the production line in St. Louis in 1979. Semi-autonomous, fire-and-soon forget air-to-air missiles like the AMRAAM, bombs steered by satellite signals, and the ever-more complex aircraft and fire control systems that facilitated their employment continued to propagate throughout the Air Force. For example, the Air Force's newest fighter, the F-35 Lightning II, requires 9½ million lines of computer code for flight operations, three times the amount needed in the service's next-newest fighter, the F-22 Raptor.[10] Commenting on the remarkable pace of development, Welch noted that "today's fighter pilot is orders of magnitude more effective than I ever was.... We give them the opportunity to do with one airplane what used to take a couple of squadrons a week to do." But, Welch also admitted, "I would never have been interested in becoming today's fighter pilot," and the former CSAF suspected that today's fighter pilots, often seemingly relegated to "simply transporting ordnance," are "probably not terribly happy about it" either.[11]

Welch's assessment is not atypical. It reflects the common tendency for fighter pilots to emphasize their own set of skills, which were optimized for their particular aircraft, while discounting the skills associated with others' aircraft and the potential personal satisfaction and professional recognition that might come with mastering the different equipment. For example, the single-seat F-22 was originally intended to be the air superiority replacement for the F-15, but it also possessed the capability to transport bombs and then deliver them against a set of GPS (Global Positioning System) coordinates entered via a telephone keypad in the cockpit. Even foregoing its air-to-ground role, the Raptor still required a dramatic shift in the tasks of the fighter pilot. Earlier in the Eagle, pilots like Welch prided themselves on being information integrators, analyzing data from a variety of sources, including the four-inch square, monochrome VSD radar display, the RWR display (located on the other side of the instrument panel from the VSD), and the extensive radio communications. In the Raptor, that information integration task was largely automated through a process known as

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[10] *Joint Strike Fighter*, 18. The F-35 relies on another 14½ million lines of code in its ground support and maintenance activities.

[11] Welch, interview, October 1, 2013.

"sensor fusion." Describing the process, one industry news report explained that Raptor pilots have "all the available data on the airspace fused and displayed on a single, easy-to-read screen." If the Raptor's computers determined a target to be hostile, the aircraft symbol on the F-22's center, eight-inch square, color display appeared in red; friendlies appeared in green; unknowns in yellow (figure 6.1). The F-22 pilot had very little insight into what sensor detected the target and caused it to appear on the display; his or her only concern was that it had appeared and its current color. Emphasizing its importance, several industry publications attributed the "F-22's unprecedented combat effectiveness" not to its radar-stealth capabilities, but to the aircraft's "ability to perform fusion of multisensor information," which, echoing the earlier promises of automation in fighter aviation, "significantly reduc[ed] the pilot workload during battle conditions."[12]

Figure 6.1. F-22 Raptor Cockpit.
(Source: Hehs, "Cockpit Photo Collection.")

Even with this high degree of automation, the fighter pilots in the Raptor were still not reduced to the push-button missilemen once feared. Rather, now freed from the information integration task, the F-22 pilots were able to shift their attention to planning in real-time their air and/or ground attacks into more heavily defended airspace, regions where aircraft like the F-15C were typically precluded from entering due to the challenging threats. Furthermore, reflective of the common historical trend, these Raptor tasks were distinct from those demanded of pilots in prior fighters. One Lockheed executive noted the shift, explaining that junior pilots plucked fresh from pilot training to fly the Raptor were performing exceptionally well, largely because "the new pilots have far fewer habits to unlearn" than the older, more experienced pilots that came from other airframes like the F-15. Moreover, contradicting Welch's appraisal, few pilots expressed their misgivings that the

[12] "F-22"; Brower, "Lockheed F-22 Raptor." For more detail on the Raptor's "sensor fusion" and its information architecture within the cockpit, see: Greeley and Schwartz, "F-22 Cockpit Avionics"; "Holding Four Aces"; "Complete Picture"; "View from the Cockpit."

automation in the Raptor was robbing them of their fighter experience, although they did occasionally acknowledge that their advantage at long-range air combat routinely limited their chances to engage in "fun" dogfight maneuvers.[13]

Far more unsettling to the fighter pilots than the automated F-22 experience was the Air Force's increasing inventory of RPAs (remotely piloted aircraft). The emergence of novel control technologies and especially high-bandwidth, low-latency satellite data transmission capabilities meant that, in the case of RPAs, pilots no longer needed to be seated in the same cockpit as their equipment; they could now perform their supervision tasks from the other side of the globe if needed (figure 6.2). With their human flesh no longer physically present in the sky, much less over the battlefield, significant controversy erupted over the professional identity and proper recognition of the RPA operators.[14] For example, in June 2012, Air Force Major Dave Blair published a short essay in the Air Force's professional journal, *Air & Space Power*, arguing that despite their physical separation from the battlespace, RPA operators should be entitled to receive combat medals for the *direct* contributions they make to battle.[15] The response to the article on the journal's website was both swift and, to a large extent, severe. Several current service members and retired veterans were appalled. "You really can't be serious, can you?"

Figure 6.2. RPA "Cockpit."
(Source: Bumiller, "Drone Pilots.")

[13] Fulghum, "Raptor's Edge"; "F-22." Of note, an F-22 commander reported of his squadron's pilots following a large air combat exercise: "We killed [the bandits] rapidly. We didn't do any major turning [during the battles]. It's not that the J-Turn maneuver [a Raptor-specific dogfighting maneuver] isn't fun, but we didn't get a chance to use it." The article noted that the F-22s amassed "144 kills to no losses during the first week of the joint service Northern Edge exercise in Alaska [in 2006], only three air-to-air 'kills' were in the visual arena—two involving AIM-9 Sidewinders and one the F-22's cannon." When an F-22 slot becomes available, the Raptor routinely goes to the top pilot training graduate; see, for example, "Lieutenant Beats Cancer."

[14] See, for example, discussions regarding the RPA operators' entitlement to "pilot" pay bonuses in Hardison, Mattock, and Lytell, *Incentive Pay for Remotely Piloted Aircraft Career Fields.*

[15] Blair, "Ten Thousand Feet and Ten Thousand Miles," 62.

questioned one respondent.[16] Reflecting a common theme in the responses, a retired Lieutenant Colonel explained, "one must experience [combat] firsthand," which, according to another Desert Storm veteran, entailed the "imminent threat of losing life or limb … while under direct fire from SAMs and AAA fire with nothing but thin sheet metal and a seat cushion in between."[17]

A few months later in February 2013, out-going Secretary of Defense, Leon Panetta, announced the creation of the Defense Department's Distinguished Warfare Medal (DWM). Acknowledging that "technological advancements have, in some cases, dramatically changed how we conduct and support combat and other military operations," Panetta directed that the new medal would recognize "extraordinary achievement, not involving acts of valor, directly impacting combat operations … regardless of … the member's physical location." The DWM was to be ranked hierarchically just below the Distinguished Flying Cross and above the Bronze Star.[18]

Panetta's announcement triggered a backlash similar to that which Blair encountered after publishing his essay. The Military Order of the Purple Heart declared in a press release that the new medal was "degrading and insulting to every American Combat Soldier, Airman, Sailor or Marine who risks his or her life and endures the daily rigors of combat in a hostile environment."[19] The Veterans of Foreign Wars likewise rebuked the Pentagon leadership, declaring, "medals that can only be earned in direct combat [like the Bronze Star and Purple Heart] must mean more than medals awarded in the rear."[20] One British

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[16] Goldsmith, "Comments on 'Ten Thousand Feet and Ten Thousand Miles.'"

[17] Howard, "Comments on 'Ten Thousand Feet and Ten Thousand Miles'"; Lamb, "Comments on 'Ten Thousand Feet and Ten Thousand Miles.'" Amidst the uproar, Blair's implicit accusation that the Air Force was mismanaging the RPA career field garnered Congressional attention, with lawmakers quickly calling for a review of RPA officers' promotion rates; see: Thompson, "Drone Pilots"; Schogol, "RPA Pilots"; Holmes, "Why Drone Pilots Deserve Medals"; "Lawmakers Ask Review." On general attitudes of and within the RPA community, see also Tirpak, "Putting the Pilot in the RPAs"; Cullen, "MQ-9 Reaper Remotely Piloted Aircraft."

[18] Panetta, "Distinguished Warfare Medal." The first Distinguished Flying Cross was awarded to Lindbergh following his solo, trans-Atlantic flight. The medal is presented to individuals who "who shall have distinguished her/himself in actual combat in support of operations by heroism or extraordinary achievement while participating in an aerial flight, subsequent to November 11, 1918." In contrast, the Bronze Star is awarded to individuals who "shall have distinguished himself by heroic or meritorious achievement or service, not involving participation in aerial flight, in connection with military operations *against an armed enemy*" (emphasis added). "Distinguished Flying Cross"; "Bronze Star."

[19] "Military Order of the Purple Heart Opposes Precedence of New Defense Medal."

[20] "VFW Believes Distinguished Warfare Medal Should Not Outrank the Bronze Star." The public outcry spurred Congressman Joe Wilson (R-SC) and forty-eight of his fellow Representatives to co-sign a letter to

commentator questioned if the new medal would "feature an armchair and a Coke machine or two crossed burgers," and many in the US wondered the same.[21] The new Secretary of Defense, Chuck Hagel, quickly shelved the new medal.[22]

The uproar over the DWM and Blair's earlier essay revealed the contempt that much of the public and the military held for the RPA operators. Even prior to the events in 2012 and 2013, it was common for RPA operators in conversations with other military pilots to be told that "flying your UAV [unmanned aerial vehicle] is like a big video game," and that the RPA job was ideally suited to the incoming "X-Box generation" of young officers.[23] On one occasion, Blair encountered a "particularly vociferous (and inebriated) F-22 pilot" who explained that the problem with RPAs, and by extension RPA operators, was that "Fighting a war via video teleconference isn't very honorable." It was a remarkably ironic assessment coming from a pilot that flew cocooned in a nearly invisible stealth fighter and performed cockpit tasks that bore little resemblance to pilots' tasks even a few years earlier.[24] But the nameless Raptor pilot's attitude wasn't unique. The director of the American Fighter Aces Association noted that many of his organization's members also regarded RPA operators as "less than true pilots."[25] A spokesperson for a Vietnam veterans' organization of fighter pilots explained, "When you tell a guy who flew an F-105 over Vietnam that this guy [in an RPA] is stressed out, he doesn't see it."[26]

While there are several ways to distinguish a traditional pilot from one that flies an RPA—the unmistakable one being that the former establishes a *physical* presence above the ground whereas the latter establishes only a *virtual* presence there—arguing on the basis of

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Panetta's replacement arguing that the proposed ranking of the DWM above the Bronze Star "is a disservice to our service members and veterans." Wilson to Hagel, March 4, 2013.

[21] Cited in Holmes, "Why Drone Pilots Deserve Medals."

[22] "Medals for Drone Warriors Canceled." On March 20, 2014, Hagel directed a "comprehensive review of the military decorations and awards program," which in part would address "the best way to recognize service members who use remote technology to directly impact combat operations, such as through cyber and remotely piloted aircraft." Garamone, "Hagel Orders Review of Military Decorations."

[23] Cullen, "MQ-9 Reaper Remotely Piloted Aircraft," 19.

[24] Blair, "Ten Thousand Feet and Ten Thousand Miles," 63.

[25] Quoted in Michaels, "Drones Change 'Top Gun' Culture." For an organization whose members wouldn't recognize the GIB-aces of the Phantom, such an attitude is hardly surprising. See also Jaffe, "Combat Generation."

[26] Michaels, "Drones Change 'Top Gun' Culture." Michaels quoted John Hope, the executive director of the Red River Valley Fighter Pilots Association, a popular organization for Vietnam veteran fighter pilots.

skill or lack thereof is misguided.[27] Indeed, the central lesson of this dissertation is that, despite the fighter pilot myth and the corresponding notions of timeless fighter pilot skills, different fighter aircraft have historically demanded different skill sets of the pilot. Hence, just as the F-86 pilots' skills were not wholly transportable to the F-4, nor the F-4 pilots' to the F-15, so too would an F-22 pilot today find his skills inappropriate if he was suddenly called upon to operate an RPA. In each historical case, certain pilot skills that were once considered challenging and central to the fighter pilot experience were adjusted, sometimes even rendered wholly irrelevant, based on the changing aircraft and automated fire control technologies. New tasks steadily emerged in their place, often as challenging if not more so than the now-out-moded skills, which collectively transformed the individual and social experience of fighter aviation.[28]

But there was one consistency in the fighter pilot experience that the pilots could always fall back on, and that was their physical presence in the cockpit of an aircraft that left *terra firma*. The modern RPA challenges this fundamental tenet of the pilot's professional identity. Hence, while RPA pilots may possess some of the same skills as a fighter pilot (and many that are also unique), and RPA pilots are just as capable of generating profound combat effects, they can no longer claim to be "something more than earthbound man." In a service that was founded on the spectacle of flight and heroic pilots, routinely celebrating both in song and verse, the physical-virtual flying distinction may be too great to overlook, regardless of internal bureaucratic directives and incentives that otherwise equate the two.[29] Simply stated, labelling RPA aviators as *pilots* may never bring them the recognition that they

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[27] *Actions Needed to Strengthen Management*, 33. Explaining the lower promotion rate for RPA operators as compared to their non-RPA peers, Headquarters Air Force officials noted that "most commanders assign less-skilled pilots and less-competent officers to [RPA] squadrons."

[28] O'Mara observed a similar phenomenon in his study of B-17 bomber aircrews during World War II. With the introduction of a new autopilot-bombsight system in the Flying Fortress, the bomber pilot was stripped of his traditional flying duties approaching the target; in their place, the pilot assumed new tasks and a new professional identity tied to his role as *aircraft commander* in charge of the entire crew's performance. O'Mara, "Socio-Technical Construction of Precision Bombing." See also the evolution of skills within the RPA community as documented in Cullen, "MQ-9 Reaper Remotely Piloted Aircraft."

[29] For example, the official Air Force song proclaims: "Off we go into the wild blue yonder, climbing high into the sun.... We live in fame or go down in flame." See also "High Flight" by John Gillespie Magee Jr.: "Oh! I have slipped the surly bonds of earth / And danced the skies on laughter-silvered wings; ... And, while with silent, lifting mind I've trod / The high untrespassed sanctity of space, / Put out my hand and touched the face of God." "History of the US Air Force Song"; "Pilot Officer John Gillespie Magee."

rightfully deserve because they will always be viewed by the public, the military, and many in the Air Force as being incapable of being *pilots* based on the type of equipment they use.[30]

There are pitfalls that must be carefully navigated if separate labels are to be applied, though. Different terms for the different operators may, for example, engender notions that automation concerns only plague RPA aviators, whereas human-machine interaction issues are exclusive to those seated in traditional aircraft. Nothing could be further from the truth. Both manned and remotely piloted aircraft involve complex and ever-evolving human-and-machine relationships, interactions that often go unappreciated when individuals or organizations focus strictly on the automated machinery or the human operator. The Department of Defense has begun to encourage its scientists and engineers to adopt this broader, human-and-machine perspective. In a July 2012 report on autonomy in defense systems, the Defense Science Board's chairman noted, "The true value of these [autonomous] systems is not to provide a direct human replacement, but rather to extend and complement human capabilities." The reports' authors similarly concluded that previous design efforts in the field of autonomy and automation had placed "too much attention on the computer rather than on the *collaboration* between the computer and its operator/supervisor to achieve the desired capabilities and effects."[31]

The responsibility doesn't reside solely with the scientists and engineers; the pilots too have a role to play fostering the human-machine perspective. For example, value can be found in finally acknowledging the widening divergence between the myth of the fighter pilot and the actual fighter pilot experience. Rather than continuing to focus on the individual tasks that a fighter pilot or RPA operator may or may not accomplish, attention should instead be directed to the effects that he or she generates over the battlefield. The focus on effects as opposed to the means used to generate them offers allows one to appreciate the expanding role and skill of RPA aviators while avoiding the otherwise questionable and naïve rhetoric that tries to convince the public that flying an RPA is the

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[30] On the continuing controversy regarding the necessary skillset for RPA aviators, and the uniqueness (or lack thereof) of that skillset relative to other manned aircraft, see Ferran, "Drone 'Stigma' Means 'Less Skilled' Pilots." It should be noted that the Air Force adopted the *pilot* label for its RPA operators during a particularly tumultuous period following the firings of the Secretary of the Air Force and the CSAF in 2008. As one senior Air Force official noted, the political environment at the time rendered it extremely difficult to label the RPA operators anything other than *pilots* due to the concern that choosing a different label might fuel the notion that the service was not fully supportive of the RPA mission. See also *Actions Needed to Strengthen Management.*

[31] *Role of Autonomy*, ii–iii. Emphasis in original.

same as flying a traditional aircraft. They aren't, and that's not a bad thing, because despite what the myth suggests, flying an F-22 or an F-15 or an F-35 aren't the same either. Human skill has not been obviated by the increasing automation in military aviation, and relying on the *pilot* term to convince the public of that fact is misguided. Just as the sailors on the *Monitor* learned in 1862, with human presence, be it physical or now virtual, comes responsibility, and with responsibility comes the potential for personal honor and heroism. That is the necessary refrain that the bureaucracy and its pilots should be preaching. .

I offer one final potential lesson. This pattern of human-and-machine coevolution amidst powerful narratives that celebrate only the operator or the machine is probably not unique to military aviation. Commercial aviation, robotic-assisted surgery, and even education have all seen the introduction of new technologies that threaten the historic identity of the user-practitioner. For example, using an autopilot to land a commercial jet isn't flying.[32] A surgeon needs to get his hands bloody.[33] A teacher needs to be standing in front of students in a lecture hall.[34] The lessons of this history of Air Force fighter aviation, the fighter pilot myth, and the role of automation therein may therefore be more broadly applicable to additional socio-technical systems and useful in future comparative research.

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[32] Buck, *Pilot's Burden*, 21–22. Buck, a former commercial airline captain, summarized the effects of technology: "When the … DC-3 came in, seat-of-the pants flying went out. While there had always been thinking pilots, until then flying basically had primarily involved fine touch on the controls, a feel for the airplane's limits, and boldness. Flying was an art. The DC-3['s] … higher performance … required the pilot to start down the road to being a technician, a direction that now takes precedence. Flying, however, periodically still needs the fine touch of the art of flying, although hard-nosed scientists believe technology can do it all."

[33] McCulloch, "Surgical Professionalism in the 21st Century." McCulloch noted that some senior surgeons worried that increasingly specialized surgical techniques and advanced technologies would challenge "the role and professional ethos of the surgeon." This would result in "a loss of professional values leading to a diminished role for the surgeon as a kind of clinical lathe operator, without any continuing responsibility for his patient—deskilled, disempowered, and easily manipulated by financial decision makers in charge of hospitals."

[34] Sibley, *Draft Report of the MITx Subcommittee*; Lin, "Group Urges Checks on Online Learning"; Shames, "Unquestioned Assumption." Like most college campuses, MIT is struggling to determine the viability of the MOOC (massive open online course) model within higher education. One internal MIT report noted the potential benefits of online education, but also emphasized "the values of face-to-face engagement between faculty and students," which included "the opportunities to develop normative sensibilities and moral commitments that will serve as lifelong guides." The chair of the MIT subcommittee therefore recommended the university "go slow, and see what's going to happen." On higher education, see also Christensen et al., *Disrupting College*. On the disruptive influence of "classroom network technologies" on traditional teaching methods in primary education (K-12), see, for example, DeBarger et al., "Teaching Routines."

Knights or Scientists?

The motivating question behind this dissertation project was, when confronted with the new, cosmic fire control technologies and their associated weaponry, would fighter pilots be able to preserve their flying knight image or would they be transformed into flying "scientists" preoccupied with the "electronic brains" in their new equipment? It was a question posed by the editors at *Life* in 1952. Based on my research and my interpretation, there was indeed a remarkable shift in the practical knowledge and skills required of a fighter pilot over the ensuing decades. Pilots necessarily became conversant in scientific topics like gigahertz radar frequencies, pulse repetition frequencies, and Doppler shifts. But the pilots also never surrendered the mystique of the traditional goggle-clad, silk scarf-wearing fighter ace, partly because the pilots always maintained a deep, personal connection with their aircraft, even though that connection was increasingly mediated by their new fire control technologies. The answer, then, is both "yes" and "no."

It was probably never an either-or proposition as first suggested. Fighter pilots have always occupied the grey area between heroic, passionate knight and more-detached, analytical scientist. Even the great aces of World War I fame were analytically minded as they struggled to learn how best to use their new machinery. Similarly, the Eagle pilots in AIMVAL-ACEVAL still possessed an intensely competitive spirit reminiscent of Richthofen. In one respect, the question seems only to propagate the "great pilot" and "great machine" dichotomy, with knights associated with the former and scientists the latter. This observation, I believe, points to a critical lesson. Rather than simply looking at the pilot *or* the gadgetry in his cockpit, more interesting revelations begin to emerge when we perceive both as working not in competition with the other, but in partnership. That is the value of adopting a human-*and*-machine perspective when investigating complex, socio-technical systems.

Perhaps a better label for the Air Force fighter pilot, instead of *knight* or *scientist*, is *tiger*. Unlike the fighter pilot's skills which had to evolve with the changing technologies, the value of an aggressive and tenacious spirit, once expressed in Korea as "Every man a tiger," is technology-agnostic.[35] The intense desire of fighter pilots to use their equipment as best

[35] The "everyman a tiger" description occasionally resurfaces; see, for example: Clancy, *Every Man a Tiger*; Beavers, "Every Man a Tiger."

they could is a common thread that runs through the history of Air Force fighter aviation. Granted, this tiger-like attitude is not unique to fighter pilots. As one ace explained during an interview, "We have all heard the old story, 'It takes a special breed of cat to be a fighter pilot.' It takes a special breed of cat to be almost anything—an interviewer, a writer, a personnel guy, a fighter pilot.... There's nothing magic about being a fighter pilot." But, to be a successful fighter pilot, the aggressive and tenacious attitude was not optional, and the ace later clarified his remarks. "Call it dedication," he said.[36] Olds echoed the assessment, "You have to want it. You have to study. You have to think."[37]

What the pilots wanted rarely changed over time, but what the pilots studied and how they thought about it did. In the F-86, it was about learning where to find the enemy and then how to outmaneuver him. In the F-4, it was about understanding the Phantom's different radar modes, the limitations of its missiles, and developing a partnership, albeit reluctantly, with the GIB. In the F-15, it meant practicing the HOTAS switchology, radar manipulation and interpretation, and inter-flight communications. While an F-4 and an F-15 pilot were not readily interchangeable, their tiger-like attitudes usually meant that they could, with enough practice and training, successfully navigate the transition and develop the required skills. Unfortunately, the distinction between the skills of a fighter pilot and the attitude of a fighter pilot are often misconstrued. As this dissertation demonstrates, the two are not necessarily related.

Fighter pilots could be both *knights* and *scientists*; but the successful ones were always *tigers*.

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[36] Roberts, Corona Ace Oral History Interview, 2–3, 24. Meyer offered a similar appraisal: "Nobody ever gets to be an ace by accident." Meyer, Oral History Interview, 3.

[37] Olds, Corona Ace Oral History Interview, 76.

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DTIC: Defense Technical Information Center, online
MIT: Massachusetts Institute of Technology Library System, Cambridge, MA
MSFRIC: Muir S. Fairchild Research Information Center, Maxwell AFB, AL
NARA: National Archives and Records Administration, online
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