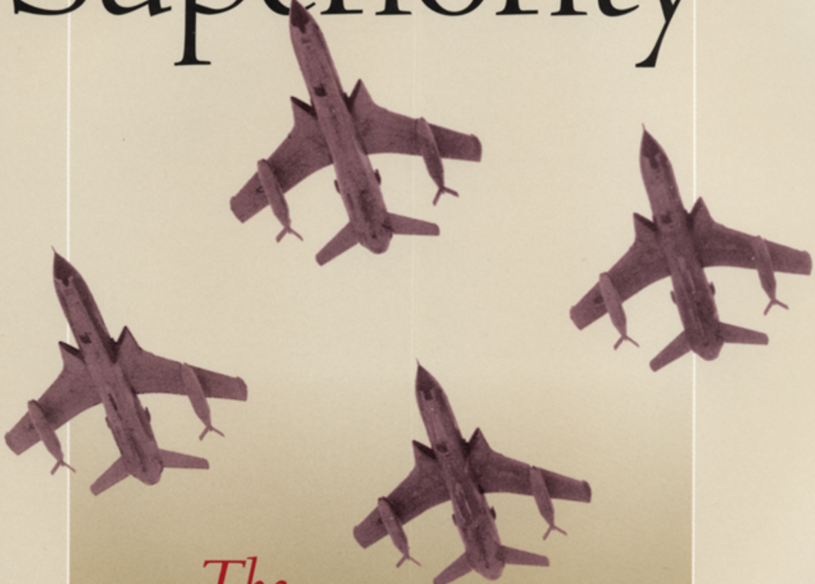
Striving for Air Superiority



The Tactical Air Command *in Vietnam*

CRAIG C. HANNAH

STRIVING FOR AIR SUPERIORITY

TEXAS A&M UNIVERSITY

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Striving for Air Superiority

THE TACTICAL AIR COMMAND IN VIETNAM

Craig C. Hannah

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To all of those who honorably served their country;
to the memory of those who sacrificed their lives for our freedom;
to the families and friends of those who never came home;
and to my wife, Melanie, for her love, patience, and understanding.

Contents

List of Illustrations ix
List of Tables xi
Preface xiii
Acknowledgments xv
Introduction 3

Chapter 1. Politics and Perceptions 21
Chapter 2. Higher, Faster, Mediocre 31
Chapter 3. Unprepared by Design 44
Chapter 4. "We're a Little Lacking There" 67
Chapter 5. An Out-and-Out Crime 89
Chapter 6. The Eagle Soars 106

Notes 113
Bibliography 127
Index 137

Illustrations

following page 66

Four Republic F-105D Thunderchiefs in a diamond formation

Fastest gunfighters in the world

A restored F-86E Sabre

An ace and his Sabre

A restored MiG-15 Fagot

The small but deadly MiG-17 Fresco

Two Air National Guard F-100D Super Sabres in formation

Lockheed's "missile with a man in it," the F-104 Starfighter

Convair's F-102 Delta Dagger

Five F-105 Thunderchiefs in flight

Lt. Jim Ray and his F-105D

F-105D pilot Col. Kennith F. Hite celebrates

McDonnell's first production F-4 Phantom II undergoing tests

Soviet MiG-21 Fishbed

An F-4C Phantom II with an SUU-16 gun pod

An Iron Hand strike force refuels

F-105F Thunderchief "Wild Weasel"

F-4G Wild Weasel

Two Vought F8 Crusaders

T-38 Aggressor in Soviet-style markings

Vought's A-7D Corsair II

F-4 Phantoms share the production line with the new F-15A Eagle

Cockpit of the F-15A Eagle

Israeli F-15 Eagle with damage

An F-15A launches an improved AIM-7F Sparrow missile

Tables

1. Total Obligational Authority in the Truman Administration 28
2. Aircraft and Related Procurement Budget in the Truman Administration 28
3. Total Obligational Authority in the Eisenhower Administration 29
4. Aircraft and Related Procurement Budget in the Eisenhower Administration 29
5. Fixed-Wing Aircraft In-flight Combat Losses by Weapon System and Branch of Service 73
6. Percentage of Fixed-Wing Aircraft In-flight Combat Losses by Weapon System and Branch of Service 73
7. Comparison of Training Sorties Flown in 1965 93
8. F-4E versus F-15 System and Miscellaneous Comparisons 111

Preface

WHENEVER POSSIBLE, THE TECHNICAL DETAILS IN THIS book were obtained from either the *Naval Air Training and Operating Procedures Standardization* (NATOPS) manuals or the Air Force Technical Orders ("Dash 1") flight manuals. Other information came from *Jane's All the World's Aircraft, Jane's American Fighting Aircraft of the 20th Century* edited by Michael Taylor, and from *The American Fighter* by Enzo Angelucci with Peter Bowers. All American aircraft loss and damage statistics were either taken directly from or were compiled from the data in the *U.S. Navy, Marine Corps, and Air Force Fixed-Wing Aircraft Losses and Damage in Southeast Asia (1962–1973) Summary* and its corresponding appendix, unless noted otherwise. The Center For Naval Analyses in Alexandria, Virginia, generously supplied the database. Most of the aeronautical engineering information and all aircraft performance formulae are from the third edition of *Introduction to Flight* by Prof. John D. Anderson, Jr.

Air force unit histories from the Vietnam War were very difficult to obtain. As of this date, only selected records of the 355th and 388th Tactical Fighter Wings have been declassified. Hopefully, their complete unit histories as well as the records of the other units that served in the war will soon be made available to the general public so that the complete story of the war waged in the skies over Southeast Asia can be told.

Acknowledgments

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STRIVING FOR AIR SUPERIORITY

Introduction

THE AFTERNOON OF JUNE 2, 1972, WAS busier than most for the men fighting the air war over North Vietnam. Through some combination of determination, luck, and divine providence, air force captain Roger C. Locher was still alive—and free. Locher had been the weapons systems operator (WSO) in the backseat of an F-4D Phantom II piloted by Maj. Robert A. Lodge on May 10, 1972, when their aircraft was shot down by a MiG-19 near the North Vietnamese airfield at Yen Bai. Major Lodge perished in the crash, but Captain Locher ejected safely and lived for twenty-three days on a diet of bananas, berries, chives, and nuts gathered from the enemy's own backyard.[1]

No one had seen the captain eject from the burning aircraft or witnessed his parachute floating to the ground, but then no communist-affiliated organization had reported the capture (or death) of another "Yankee Air Pirate." Thus, Captain Locher's fate remained a mystery until the first day of June. On that day, a flight of air force Phantoms from the 8th Tactical Fighter Wing (TFW) were returning from a strike at Yen Bai when they happened to pass directly over Captain Locher's position. The captain sent a brief message over his survival radio to the passing aircraft, and Lt. James Dunn heard Captain Locher say, "Any U.S. aircraft, if you read Oyster One Bravo, come up on Guard."[2] Five minutes later, another flight of homeward-bound Phantoms established communication with Captain Locher, confirmed that he was not transmitting under duress, and verified his position. The air force and navy commands promptly began planning how to rescue a downed airman who was certainly weakened from fatigue and malnutrition, probably injured, and hiding only eight miles away from an enemy airfield.

The rescue attempt required near-perfect timing and a tremendous amount of cooperation between the strike aircraft of the U.S. Air Force's Tactical Air Command (TAC), the aerial refueling aircraft of the U.S. Air Force's Strategic Air Command (SAC), and U.S. Navy aircraft carriers cruising in the northern Gulf of Tonkin. The plan to rescue the captain was quite simple in theory: the navy would launch strikes against Haiphong and the eastern Hanoi area, while the air force would stage a massive strike over western Hanoi. The joint missions would hopefully divert North Vietnamese air defenses long enough for the HH-53 Super Jolly Green Giant rescue helicopters and their A-1 Skyraider escorts to sneak into enemy airspace and extricate Captain Locher without themselves being detected.

Major Phillip Handley of the 432nd Tactical Reconnaissance Wing's (TRW) 58th Tactical Fighter Squadron (TFS) was leading Brenda flight that day on a Combat Air Patrol (CAP) mission forty miles northeast of Hanoi, between the MiG airfields at Gia Lam and Kep.[3] First Lieutenant John Smallwood was busy monitoring the radar and radios in the back seat of Major Handley's F-4E when the radar homing and warning (RHAW) equipment in all four of the Brenda flight aircraft suddenly came alive. The warning lights and audible tones from the RHAW system indicated that the North Vietnamese had launched an SA-2 surface-to-air missile (SAM) at Brenda flight as it performed a cross turn reversal at the southern end of its CAP orbit. Although he suspected that the launch warning was a ruse, Major Handley commanded the flight to "turn into the missile launch and take it down."

During the breaking turn to defeat the missile, Lt. Col. John Downey in Brenda 03, and his wingman Capt. Robert Ellis in Brenda 04, became separated from and lost sight of Brenda elements 01 and 02. To make matters more complicated, the two trailing elements in Brenda flight then reached "Bingo" fuel, or the minimum amount of fuel required to safely reach the aerial refueling tankers that were circling over the Tonkin Gulf. Captain Ellis in Brenda 04 quickly moved into line abreast formation with Lieutenant Colonel Downey in Brenda 03, and the two Phantoms headed east.

At precisely the same time that Major Handley's flight was turning and diving toward the missile, the North Vietnamese Integrated Air Defense System launched two silver-colored MiG-19 Farmers from the air base at Gia Lam. Flying in full afterburner, the two enemy aircraft hugged the ground in order to minimize their exposure to

American radar. The Mig-19 pilots streaked toward Brenda flight, hoping that the Phantom pilots were preoccupied with the spurious SAM launch and would be easy prey for a surprise attack. The enemy lost the element of surprise however, when "Worm," the Red Crown controller assigned to Brenda flight warned Major Handley that MiGs were approaching from his two o'clock position at a distance of eight miles. Red Crown was the code name for U.S. Navy cruisers in the Tonkin Gulf that electronically monitored all aerial activity in the region.

Seconds after Major Handley ordered a turn into the attacking MiGs, Capt. Stanley Green in the front cockpit of Brenda 02 reported that he too had reached "Bingo" fuel. Frustrated with the rapidly deteriorating situation, the major called for a turn to the east. Brenda 01 and Brenda 02 then headed out of their assigned patrol area in a line abreast formation at approximately fifteen thousand feet and an airspeed of between 450 and 475 knots.

During this maneuver, Major Handley saw a reflection through a break in the clouds. The glimmer, which disappeared as quickly as it had appeared, was approximately five thousand feet below and to the right. The tension rose as the location of the MiG-19s remained uncertain, but the onboard RHAW gear soon located a very weak radar ranging signal coming from the Phantoms' right-rear quarter. The major then moved Brenda 02 from his right wing to his left wing. Each of the two pilots and their WSOs searched diligently for a glimpse of the small, silvery airplanes. After what seemed like an eternity but in reality was less than twenty seconds, Major Handley spotted two MiG-19s in an offset, trail formation at his right, five-o'clock position less than a mile and a half away.

Since Brenda 02 had reached "Bingo" fuel, the major told Captain Green to continue on to the rendezvous with the fuel tankers over the Gulf while he made a firing pass at the MiG-19s. In a firm but calm voice, Captain Green, with 1st Lt. Douglas Eden in the rear cockpit of Brenda 02, replied, "I'll stay with you." With the knowledge that Brenda 02 was providing cover at an altitude of ten thousand feet, Major Handley slammed the twin throttles of his Phantom forward into full, fourth stage afterburner while executing a right, seven-g, slicing turn into the MiGs.

The major distinctly felt the heavy aircraft accelerate through the speed of sound after approximately ninety degrees of turn. Just as Brenda 01 went supersonic, the MiG formation inexplicably abandoned its "curve of pursuit attack" and turned left—away from the slicing Brenda 01. The two MiGs then resumed a right, descending turn. Flying at faster than the speed of sound, Brenda 01 was within two miles of the trailing MiG-19 and closing rapidly.

As the MiGs continued their sharp right turn, Major Handley relaxed his turn rate so that the flight path of his Phantom lagged behind that of the MiGs. This reduced the "angle-off" between the two airplanes once air-to-air missile firing parameters were obtained. Expertly manipulating the F-4's powerful radar, Lieutenant Smallwood soon acquired the trailing MiG-19. Major Handley then waited for the required four seconds to pass before "ripple firing" his two radar-guided AIM-7 Sparrow missiles. The tracking avionics in the missile needed four seconds to "settle" once a target had been acquired. As the two missiles were sequentially released from the cavities on the bottom of the Phantom's fuselage, the rocket motor in the first missile failed to ignite, and the second Sparrow went off on an unguided, ballistic trajectory. Out of Sparrow missiles, the crew of Brenda 01 prepared to fire their two infrared-guided AIM-4E Falcon missiles. To improve his chances for a missile kill, Major Handley executed a lag-pursuit roll to the outside of the turn to further reduce the angle-off between the path of his Phantom and that of the MiGs.

The two men in Brenda 01 then heard a growl that reminded them of a "Norelco electric shaver." The tone indicated that the missile's avionics systems were active. The volume and pitch of the tone increased rapidly as Major Handley aimed the F-4E's gun sight at the afterburner plumes of the trailing MiG-19. As the tone steadily increased, the major depressed a button on the control stick grip that uncaged the seeker heads of the AIM-4E missiles. He then pointed the Phantom's nose ahead of the flight path of the MiG and "ripple fired" his remaining two missiles. Throughout the long war in Southeast Asia, the performance of the AIM-4 missile had remained consistent—consistently bad—and the two missiles fired by Major Handley also failed to perform. The first missile never left its under-wing pylon, and the second missile sped off on an unguided ballistic arc.

After expending the energy produced by burning a thousand pounds of fuel and converting approximately thirteen thousand feet worth of potential energy into kinetic energy in the diving, slicing turn, Brenda 01 was now thundering through the sky at 818 knots (Mach 1.2) at an altitude of two thousand feet. The trailing MiG-19 maintained its hard right turn at six hundred feet above ground and at near supersonic speed. The distance between Brenda 01 and the trailing MiG-19 was now about three thousand feet and closing rapidly. Apparently seeing the smoke trail from the second Falcon missile, the two MiG-19s turned sharply into the attacking F-4. Their flight path was now nearly perpendicular to that of the Phantom's. Without looking down into the cockpit, Major Handley once again reset the armament switches on the lower left corner of the instrument panel to select the F-4E's internal 20-mm Gatling gun.

The major was now less than five hundred feet above the ground—still in a seven-g turn and closing on the trailing MiG-19 at a rate of over thirteen hundred feet per second. Placing the Phantom's nose well ahead of the perpendicular flight path of the hard-turning MiG, Major Handley pulled the trigger that activated the General Electric M61 Gatling gun. Within milliseconds, three hundred 20-mm cannon rounds arced forward into the airspace about to be occupied by the North Vietnamese fighter. At a slant range of less than three hundred feet to the target, years of experience and gunnery practice were rewarded as the high explosive and armor piercing incendiary rounds walked squarely down the MiG's fuselage.

As he passed the MiG, Major Handley rolled sharply ninety degrees to the left and pulled up into a near vertical climb while continuing to observe his adversary, who was now at his three o'clock low position. The mortally wounded fighter was mushing through the sky, its wings rocking violently from one side to the other. Fire, vital fluids, and debris flowed from its right wing root into the slipstream. Major Handley and Lieutenant Smallwood watched the nose of the stricken MiG continue to drop until it was in a near-vertical dive. The North Vietnamese fighter then crashed into a green rice paddy and exploded in a bright orange ball of fire. A mere ten seconds had elapsed since the major first pulled the trigger.

The surviving MiG-19 continued its hard right turn in a vain attempt to follow the steeply climbing Phantom. Captain Green in Brenda 02, still covering Brenda 01 from his altitude of ten thousand feet, advised Major Handley of the MiG-19's position and hostile intent and suggested, "Let's get out of here." It was time for Brenda 01 and Brenda 02 to rendezvous with a KC-135 tanker over the Tonkin Gulf. The two Phantoms flew eastward in a line abreast formation with two thousand feet between them. Only four minutes and forty-eight seconds had elapsed since Brenda flight first received the warning from "Worm."

After years of practice and study in air combat maneuvering and tactics, after the determined efforts of leaders such as Gen. Frederick Blesse to mount an internal cannon in the F-4 Phantom, and with some measure of luck, the crew of Brenda 01 made history on that summer day in 1972. Their engagement was the first recorded kill made by an internally mounted gun in the F-4, the only MiG-19 shot down with a gun during the course of the war in Southeast Asia, and it is clearly believed to be the fastest gun kill ever recorded. It had been a very good day for most of the Americans who fought in the skies over Southeast Asia: Major Handley and Lieutenant Smallwood downed a MiG-19 and Captain Locher was rescued after surviving twenty-three days in hiding near the North Vietnamese capital.[4]

The cannon-equipped F-4 Phantom and many other items involved in the rescue of Captain Locher would not have existed had TAC not performed a philosophical, command-wide "reversing maneuver" in the late 1960s and early 1970s in order to correct the mistakes made in the aftermath of World War II. The War Department created the Tactical Air Command on March 21, 1946, at Drew Field, Florida, and charged it with providing air superiority over the battlefield; providing tactical interdiction of enemy forces, their lines of communication, and their supplies; providing tactical reconnaissance; and with providing tactical airlift of troops and material. A critical analysis of TAC's performance in the Vietnam War would require volumes. Therefore, this work will focus primarily upon TAC's ability to control the airspace and to provide tactical interdiction over North Vietnam. The contributions of those who provided either tactical reconnaissance or airlift, however, should not be ignored.

Active U.S. Air Force participation in the war in Southeast Asia did not begin with the first Rolling Thunder strikes in March, 1965, but several years earlier when TAC reconnaissance crews recorded the very beginnings of communist aggression in Southeast Asia. In early 1961, the Royal Laotian government requested air support from the United States, and the air force promptly dispatched an SC-47 Skytrain to photograph the increasing presence of the Pathet Lao and North Vietnamese forces in the Plain of Jars. The propeller-driven SC-47 was shot down on March 23, and a subsonic RT-33 Shooting Star continued the mission until a detachment of supersonic RF-101 Voodoos arrived in November, 1961, as a part of Operation Farm Gate. The RF-101s proved to the world that the Soviet Union was arming both the Pathet Lao and North Vietnamese forces in Laos when they intercepted and photographed a Soviet cargo aircraft dropping supplies to the communist troops on October 23, 1961.[5]

Along with the RF-101 Voodoos, TAC sent four World War II–era RB-26 Invaders to Southeast Asia under the Farm Gate program.[6] The tactical reconnaissance effort in South Vietnam expanded once again in the spring of 1963 when two RB-57E Canberras arrived at Tan Son Nhut Air Base. Compared to the RB-26s and RF-101s, the Canberras offered a substantial improvement in intelligence gathering capabilities since they contained both infrared sensors and panoramic cameras. Two of the RB-26s were also modified for night photography, and TAC activated the 13th Tactical Reconnaissance Technical Squadron at Tan Son Nhut to better manage the growing number of assets.[7]

The nearly twenty years' worth of constant use had taken a toll on the B-26 Invaders, however, and the air force retired all B-26 and RB-26s from the inventory in 1964. Tactical Air Command sent two additional RF-101Cs as replacements for the Invaders. Reconnaissance flights over the Laotian portion of the Ho Chi Minh Trail and the Plain of Jars continued throughout 1964, and a task force of RF-101s arrived at Udorn Royal Thai Air Base in April, 1965, to provide improved coverage in northern Laos. The Udorn detachment also received permission to penetrate North Vietnamese airspace.[8]

The demand for tactical reconnaissance increased dramatically as the hostilities in South Vietnam escalated in the mid-1960s. To carry the additional burden, TAC assigned the 20th Tactical Reconnaissance Squadron (TRS) and its sixteen RF-101Cs to Udorn in March, 1966. Eleven additional RF-4C Phantoms joined the squadron in July and ten more in November 1966. During that same month, the Phantom detachment became the 11th TRS.[9] In September, 1966, the 432nd TRW took command of all Thailand-based reconnaissance aircraft. The 460th TRW at Tan Son Nhut Air Base provided tactical reconnaissance for all of South Vietnam. It was both the largest wing in the war zone and the most diverse since the wing operated seven different aircraft types.[10]

Knowing the value of tactical reconnaissance, the North Vietnamese MiG pilots frequently attempted to intercept and destroy the unarmed RF-101 and RF-4C aircraft. The supersonic Voodoos and Phantoms could run away from the older, subsonic MiG-17 Frescos, but the newer, supersonic MiG-21 Fishbed proved challenging. On September 16, 1967, a North Vietnamese MiG shot down an RF-

101C piloted by Maj. B. R. Bagley of the 20th TRS.[11] Consequently, the air force prohibited RF-101Cs from penetrating North Vietnamese airspace and relocated the planes to Tan Son Nhut Air Base. The Voodoos continued to provide vital information for those who controlled the war in South Vietnam and Laos until November, 1970.[12]

The North Vietnamese assault of the Marine Corps base at Khe Sanh, which began on January 21, 1968, and the subsequent Tet Offensive marked the busiest period of the war for TAC reconnaissance units. To cope with the crisis, both the air force and the army sent every available photo interpreter from around the world to Tan Son Nhut. By March 31, 1968, TAC reconnaissance pilots had flown almost fourteen hundred missions, and photo interpreters examined over a million feet of film.[13]

As the Tet Offensive concluded, Pres. Lyndon B. Johnson ordered a bombing halt over North Vietnam on April 1, 1968. The bombing halt effectively ended tactical reconnaissance flights over North Vietnam, but operations continued over both Laos and South Vietnam. The president finally permitted RF-4Cs with armed escorts to penetrate the southern portion of North Vietnam on October 31, 1968, while the SR-71 Blackbird and unmanned SAC drones covered the northern regions of North Vietnam.

With the election of Pres. Richard M. Nixon in 1968, American involvement in Southeast Asia steadily declined, with the brief exception of the invasion of Cambodia in 1970. The TAC inactivated the 460th TRW in March, 1971, and the RB-57s left Southeast Asia in August of that year. Only one TAC reconnaissance squadron with its complement of twenty-four RF-4C Phantoms remained in Southeast Asia.[14] The dedicated air and ground crews from that lone squadron (with some assistance from South Vietnamese Air Force RF-5 Tigers) provided all of the tactical reconnaissance during the busy days of the 1972 Easter Offensive, Operation Linebacker I, and Operation Linebacker II.

Aerial operations over North Vietnam officially ended on January 27, 1973, but tactical reconnaissance sorties over Laos, Cambodia, and the demilitarized zone between North and South Vietnam continued until August 15. In twelve years of continuous operations, TAC reconnaissance aircraft flew nearly 650,000 missions.[15] The TAC lost a total of 113 reconnaissance aircraft of all types, including seventy RF-4C Phantoms and thirty-two RF-101 Voodoos. Aircraft flying tactical reconnaissance missions accounted for 11 percent of all air force fixed-wing in-flight combat losses during the Vietnam War.[16]

Tactical airlift operations in the Vietnam War commenced on November 16, 1961, when four C-47 Skytrains landed at Bien Hoa Air Base. Flying both day and night, the Operation Farm Gate airlift teams provided transportation for South Vietnamese paratroopers, dropped flares to illuminate the battlefield at night, supplied U.S. Army Special Forces camps throughout South Vietnam, and supported other Farm Gate–related programs as necessary. The Skytrain crews received some much-needed assistance a month later when sixteen C-123 Providers arrived in Vietnam. By 1964, the number of C-123 aircraft in South Vietnam filled four squadrons, all under the command of the 315th Air Commando Wing. The Provider served as the principal airlift asset in Southeast Asia until the arrival of the C-130 Hercules in 1965, and it continued serving in the theater until 1970.[17]

While the C-123K could carry a maximum payload of fifteen thousand pounds, the C-130 Hercules could carry a maximum payload of 43,811 pounds—nearly three times the usable load of a Provider—while still operating from the most rugged of airstrips.[18] One could gage the expansion of American forces in Southeast Asia simply by counting the number of C-130s assigned to South Vietnam. In December, 1965, TAC had a total of thirty-two C-130s in South Vietnam. Fourteen months later, during the Tet Offensive, the number of C-130s assigned to South Vietnam had tripled to a total of ninety-six aircraft.[19]

From November, 1961, to the spring of 1966, the Common Service Airlift System and the Airlift Control Center (ALCC) at Tan Son Nhut Air Base controlled tactical airlift in Vietnam. The Military Assistance Command–Vietnam (MACV) headquarters then created the Joint Movements Transportation Board and the Traffic Management Agency to coordinate tactical airlift operations. Both of these organizations reported to the 834th Air Division. The transportation board focused on forecasting monthly airlift requirements and making the necessary adjustments. The Traffic Management Agency assigned airlift priorities on a daily basis, and the ALCC continued to schedule aircraft and missions. In the event of a crisis, the MACV Command Operations Center could bypass the above organizations and schedule tactical airlift missions.[20]

Late in the war, interservice rivalries resulted in TAC gaining a remarkable tactical airlift asset. The de Havilland CV-2A Caribou, as flown by the U.S. Army, was a twin-engine, all-weather, short takeoff and landing (STOL) utility transport. It could carry a maximum payload of 8,740 pounds while needing only 1,185 feet of runway to clear a fifty-foot-tall obstacle.[21] Although the army had operated a relatively large fleet of Caribou aircraft since 1959, the air force argued that it alone had the authority to provide fixed-wing tactical airlift. Years of intense and often acrimonious debate over tactical airlift in support of infantry operations finally resulted in the army transferring its fleet of CV-2As to the air force on January 1, 1967. The six army companies became air force squadrons under the command of the 483rd Tactical Airlift Wing, and the aircraft was renamed the C-7A.[22]

Thousands of American, South Vietnamese, Republic of Korean, and Australian infantrymen owe their lives to the heroic efforts of the air force crews who provided tactical airlift. For example, when the North Vietnamese Army attempted to overrun the Plei Me Special Forces camp in the fall of 1965, TAC responded by delivering a daily average of 186 tons of supplies to the army's 1st Cavalry Division.[23] During the battle for Khe Sanh, the air force delivered 12,400 tons of supplies to the marine defenders despite terrible weather and concentrated enemy fire from the communist forces surrounding the base.[24]

The greatest challenge for air force tactical airlift crews, however, occurred during the 1972 Easter Offensive when North Vietnamese forces attacked the cities of Kontum and An Loc. Enemy gunfire limited the air force to operating mostly at night and to delivering the cargo by parachute, which was both hazardous and very inefficient. The cargo parachutes often failed, and barrages of communist automatic weapons fire forced the airlift crews to release the payload at higher than ideal altitudes. Thus, the supplies so critical to the defense of both Kontum and An Loc were frequently either destroyed or captured by the enemy. The air force finally resolved the cargo delivery problems by sending experienced parachute riggers from Okinawa to South Vietnam.[25]

From 1962 to 1973, TAC delivered over seven million tons of passengers and supplies in Southeast Asia. The cost in both men and machines, however, was significant. Two hundred and sixty-nine officers and men were either killed in action or listed as missing in action, and twenty C-7A Caribous, fifty-three C-123 Providers, and fifty-three C-130 Hercules aircraft were destroyed.[26]

Losses and missed opportunities during the Vietnam War forced TAC to change many institutional policies that it had created during the 1950s. For example, Pres. Dwight D. Eisenhower's "New Look" defense policy relied primarily upon nuclear weapons to deter communist aggression and expansion. This policy was based upon the knowledge that the United States had nuclear superiority over the Soviet Union, and a nuclear arsenal was thought to be cheaper to build and maintain than a large army, navy, and tactical air force. Thus, SAC's massive intercontinental bombers received a disproportionate share of the defense budget during that period, and TAC felt compelled to incorporate tactical nuclear weapons into its arsenal in order to justify its existence. Instead of focusing upon its primary missions as dictated by the War Department in 1946, TAC developed into a miniature version of SAC.

The Tactical Air Command was plagued with an identity crisis throughout the 1950s, primarily because the Strategic Air Command's budgetary dominance seemed likely to destroy it. In order to justify funds and, in fact, to survive, TAC concentrated upon striking fixed targets with nuclear weapons. This focus on delivering tactical nuclear weapons, however, left TAC with too few resources to devote to an essential part of the mission: air superiority. Intercepting enemy bombers became the primary type of air-to-air mission for which TAC fighter pilots trained. Accordingly, the fundamentals of fighter-versus-fighter tactics received much less attention in the briefing rooms of and in the practice missions flown by the operational tactical units. The financial constraints placed upon TAC during this period further weakened the service in a manner that Congress had not anticipated. Squadron commanders necessarily put safety first and became overly concerned with preventing loss or damage to their now-scarce assets and restricted their pilots from executing many seemingly high-risk air combat maneuvers in training flights. Preserving fighter aircraft took precedence over preparedness. Furthermore, the limited amount of air combat maneuvering training that air force fighter pilots received was not very realistic: air force pilots and navy aviators trained in air-to-air combat against like aircraft flown by pilots who employed tactics similar to their own.

The introduction of the beyond visual range air-to-air missile in

1962 also affected the air-superiority mission. Politicians, the press, the public, and many others in both the defense industry and in the military believed that dogfights would now only occur in movies about World War II and Korea. Instead of a close turning fight with the enemy, pilots in the near future would obtain a radar lock on their adversary and destroy him with a radar-guided missile long before they could possibly see him with their own eyes. To many, cannon-equipped aircraft seemed as obsolete as the spear.

These factors combined to render TAC unprepared for the rather conventional air war over Southeast Asia. Tactical Air Command entered the war in Vietnam with the wrong equipment, and many of its fighter pilots were not adequately trained in air combat maneuvering. Supersonic interceptors and tactical nuclear bombers, such as the F-4 Phantom II and the F-105 Thunderchief, had a difficult time coping with the small, highly maneuverable MiGs of the North Vietnamese Air Force. Political restrictions, the complicated command structure, training, and equipment failures severely limited the effectiveness of the radar-guided missiles. Many TAC pilots were simply not prepared for the hit-and-run tactics used by the North Vietnamese.

The air force was also unprepared to counter surface-to-air missiles. The first Soviet SAM reached operational status in 1955. An improved version of the missile, known as the SA-2, downed the U-2 reconnaissance airplane flown by Francis Gary Powers on 1 May 1960, and an SA-2 also destroyed the U-2 flown by Maj. Rudolph Anderson during the Cuban missile crisis in October, 1962. The SA-2 first appeared in North Vietnam in April, 1965, and an SA-2 destroyed an air force F-4 Phantom near Hanoi on July 24, 1965. Between 1955 and 1965, however, the air force made no concentrated effort to develop a surface-to-air missile countermeasure. As a defensive measure, the air force in the latter half of 1965 lowered the mission altitudes to below the minimum effective altitude of the SA-2 (two thousand feet). However, this decision placed the strike aircraft well within the lethal range of radar-guided antiaircraft artillery, automatic weapons, and small-arms fire.

By the late 1960s, the air force realized that it had some very serious problems and began to rethink its tactics, training, and procurement practices to halt the decline of the past two decades and save itself. First, the air force formed a committee to resolve the surface-to-air missile menace. This led to the development of Wild Weasel aircraft and pod-mounted electronic countermeasures equipment. The TAC also labored to correct some of the design problems with the F-105 and F-4 aircraft—problems that had their genesis in 1950s politics but were hindering the American performance in Vietnam.

In October, 1965, the air force chose to evaluate the navy's A7 Corsair II as a replacement for the A-1 Skyraider, F-100 Super Sabre, and F-105 Thunderchief. Three years later, the air force accepted the A-7D. This decision was important for many reasons. The navy's experience with the Corsair proved conclusively that a simple, rugged, inexpensive, subsonic aircraft with a precision ordnance delivery system is more effective for close air support and interdiction bombing than an expensive, complicated, supersonic jet. More importantly, the A-7D needed fighter escort for protection from MiGs. Thus, the Corsair II created a need for a new air-superiority aircraft, which in turn led to the development of the F-15 Eagle.

The final phase of the reverse was not initiated until the last few months of the air war in Vietnam. In the summer of 1972, the air force taught an advanced but abbreviated course in air combat maneuvering to a select group of fighter pilots under the "Top Off" program. In that same year, TAC also initiated several successful "Air-to-Air Capabilities Improvement Programs." After the war, the air force created the Fighter Lead-In Program to better prepare the graduates of undergraduate pilot training for frontline fighter aircraft. Both basic fighter maneuvers and advanced air combat maneuvering were emphasized in the Fighter Lead-In Program.

The establishment of the Aggressor squadrons and Red Flag exercises in the postwar years became arguably the most important part of the policy reversal in that pilots practiced air combat tactics in realistic situations. Aggressor pilots, who used Soviet-style tactics in aircraft that performed similarly to MiGs, regularly flew practice missions against TAC fighter pilots. The Red Flag exercises at Nellis Air Force Base (AFB), Nevada, provided all air force squadrons with a very realistic, simulated war against Soviet-trained forces. Red Flag created an exact training environment by using the Aggressors and simulated SAMs, radar-guided antiaircraft artillery, and automatic weapons in the exercises. The Aggressors and Red Flag provided pilots with the experience needed to survive in modern air combat.

One may notice that the political aspects of the Vietnam War and, to some degree, interservice rivalries and politics, have been avoided in this study as much as possible. The infamous rules of engagement certainly contributed to the overall poor performance of the air force and navy in Southeast Asia, but the senior commanders of both services had virtually no control over that situation. Those interested in understanding how the rules of engagement limited U.S. effectiveness in the air war over North Vietnam should read the following: *Going Downtown: The War against Hanoi and Washington* by Jacksel Broughton, *On Yankee Station: The Naval Air War in Vietnam* by John B. Nichols and Barrett Tillman, and "Testing the Rules of Engagement" by Joe Patrick in *Vietnam* magazine.[27]

In his scathing critique of Presidents Kennedy and Johnson, Secretary of Defense Robert S. McNamara, and the Joint Chiefs of Staff during the first half of the 1960s, H. R. McMaster argues that interservice rivalries and the idiosyncrasies of Johnson and McNamara combined to make whatever advice the Joint Chiefs of Staff (JCS) and other senior military advisers offered virtually irrelevant. For example, shortly after Kennedy appointed Gen. Maxwell D. Taylor to the newly created position of military representative of the president in 1961, "Taylor discovered that McNamara often suppressed JCS advice in favor of the views of his civilian analysts. On several defense issues McNamara either failed to consult the JCS or did not forward their views to the White House."[28] McNamara's duplicity did not end with Kennedy's fateful trip to Dallas but instead worsened during the Johnson administration. Concerning Johnson's "profound insecurity," McMaster states: "Above all President Johnson needed reassurance. He wanted advisers who would tell him what he wanted to hear, who would find solutions even if there were none to be found. Bearers of bad news or those who expressed views that ran counter to his priorities would hold little sway."[29]

President Johnson once boasted that the military "couldn't even hit an outhouse without my permission," and the results of his long-distance micromanagement were disastrous. As Col. Jacksel Broughton, the former vice commander of the 355th TFW at Takhli Royal Thai Air Force Base wrote: "We knew we were better qualified to sort out outhouses at five hundred knots than Johnson was, especially when those outhouses started shooting at us. He and McNamara lost a bunch of good people and good machinery all over Southeast Asia with their outhouse mentality of the war."[30] Although the political mismanagement of the war certainly caused a multitude of problems, the fact remains that the Tactical Air Command had many internal problems that impeded its performance. No organization founded and operated by humans is flawless.

The command structure in Southeast Asia also led to gross inefficiencies in the conduct of the air war and thus reduced the performance of all the services. While addressing the twenty-second national convention of the Air Force Association in 1968, air force Director of Operations Maj. Gen. George B. Simler told the audience that "While the command interrelations are complicated and less than perfect, they are a fact of life and are being made to operate satisfactorily through the individual initiative and dedication of all concerned."[31] The general's statement typifies the bureaucratic malaise that permeated both the federal government and the military in the 1960s. Everyone knew that there was a problem, but those with the ability to improve the situation were reluctant to exert their authority.

During the critical years of 1965 to 1969, President Johnson, Secretary of State Dean Rusk, Defense Secretary McNamara, National Security Adviser McGeorge Bundy (later replaced by Walt Rostow), Press Secretary Bill Moyers (later replaced by George Christian), and Central Intelligence Agency director Richard Helms met for lunch nearly every Tuesday in the White House family quarters. The president and his advisers discussed the conduct of the air war and attempted to reach a consensus decision over which targets were to be destroyed and how much force would be applied. It is worth noting that the chairman of the JCS, Gen. Earle G. Wheeler was not invited to attend the lunchtime meetings until late 1967. General Wheeler was the only military representative ever invited to the conferences.

Once the targets were selected, either Secretary McNamara or General Wheeler would then provide the list to Adm. Ulysses S. Grant Sharp, who was the Commander in Chief, Pacific (CINCPAC) at Pearl Harbor. Below that level, the command line became increasingly complicated. Both the Commander in Chief, Pacific Air Forces (CINCPACAF), and the Commander in Chief, Pacific Fleet (CINCPACFLEET), reported to CINCPAC. Colonel Broughton remarked that CINCPACAF "ruled the air force in the Pacific and . . . controlled all air operations to the most minute detail. The common complaint about PACAF headquarters was its detachment [from the war] and lack of current professional knowledge. The majority of that staff were not familiar with the operational equipment or with the involvement of the pilots and the equipment during combat missions over the North."[32]

The commander of the 2nd Air Division, which later became the Seventh Air Force, at Tan Son Nhut Air Base in Saigon exercised operational control over air force tactical units in Southeast Asia. The Thirteenth Air Force at Clark Air Base in the Philippines provided administrative and logistical control.[33] Carrier Task Force 77 and the III Marine Amphibious Force answered to the CINCPACFLEET. Should the military wish to attack a target that was not already approved, the cumbersome process theoretically worked in reverse. When asked about this issue, Colonel Broughton observed: "In truth, nothing ever worked in reverse to my knowledge. Ideas from operating wing level and below were automatically considered no good. The only person who could speak going up [the chain of command] was Admiral Sharp . . . and he always got told NO!"[34]

The situation improved dramatically with the election of President Nixon. Although attacks into most of North Vietnam were prohibited except for "protective reaction" strikes, both the chain of command and the rules of engagement were significantly reduced. The Seventh Air Force commander was at last permitted to establish his own list of priority targets and to determine the size and composition of the strike force, which he did with unprecedented fury during the Operation Linebacker campaign from April to October, 1972.[35]

The Seventh Air Force commander also served as MACV's deputy commander for air. Whereas CINCPAC conducted aerial operations in Cambodia, Laos, and most of North Vietnam, MACV managed the air war in South Vietnam and in the extreme southern region of North Vietnam. Further complicating the situation, the aircraft of Carrier Task Force 77 operated over the same areas of North and South Vietnam, Laos, and Cambodia. The Seventh Air Force commander controlled all of the U.S. Air Force assets in South Vietnam and select U.S. Marine Corps assets but had no authority over the army's fixed-wing aircraft or helicopters. He also had no authority over the KC-135 aerial refueling aircraft, the B-52 Stratofortress heavy bomber force based on Guam, the SR-71 Blackbird strategic reconnaissance airplanes stationed on Okinawa, and the U-2 strategic reconnaissance aircraft based at either Bien Hoa or Utapao. The Strategic Air Command likewise refused to yield control of its assets to MACV.[36]

Although it was a model of inefficiency, this cumbersome command structure functioned daily for nearly eight years. One can only imagine the level of effort required to execute a basic interdiction mission over North Vietnam, much less the difficulty involved in coordinating the rescue of Captain Locher. Fortunately for the United States, the small North Vietnamese Air Force lacked the men and matériel to wage an offensive air war. Had the North Vietnamese possessed resources comparable to those of either the German Luftwaffe or the Empire of Japan in World War II, the air force could have suffered devastating losses.

CHAPTER 1

Politics and Perceptions

According to air force folklore, Gen. James H. "Jimmy" Doolittle once defined the two types of airpower as follows: "Tactical bombing is breaking the milk bottle. Strategic bombing is killing the cow." Doolittle's definition, if he actually made such a statement, was reasonably accurate. The Tactical Air Command was responsible for supporting the infantry, interdicting enemy supplies, and for controlling the airspace above the battlefield. The history of the Tactical Air Command between the end of World War II and the first Rolling Thunder mission of the Vietnam War is a complex tale of politics and perceptions. American foreign policy, intraservice politics, and TAC's perception of the above led it to neglect the air-superiority mission during those crucial years before the Vietnam War. As a consequence, the air force was unprepared for the air war in Southeast Asia.[1]

No one doubted that control of the air was critical to the Allied victory in World War II. In December, 1943, Gen. Henry H. "Hap" Arnold warned the commanding generals of the Eighth and Fifteenth Air Forces: "It is a conceded fact that OVERLORD [the Normandy invasion] and ANVIL [the proposed invasion of southern France] will not be possible unless the German Air Force is destroyed. Therefore, my personal message to you—this is a MUST—is to, *"Destroy the Enemy Air Force wherever you find them, in the air, on the ground and in the factories."*[2]

After the war, Pres. Harry S Truman gathered a diverse group of civilians and military officials to examine the effectiveness of the strategic bombing campaigns in both Europe and the Pacific, and their conclusions were summarized in the *United States Strategic*

Bombing Survey. The committee members also investigated the importance of air superiority to the overall success of strategic aerial warfare. As for the European theater, the commission decided: "The significance of full domination of the air over the enemy—both over its armed forces and over its sustaining economy—must be emphasized. That domination of the air was essential. Without it, attacks on the basic economy of the enemy could not have been delivered in sufficient force and with sufficient freedom to bring effective and lasting results."[3] The authors of the *United States Strategic Bombing Survey* reached the same conclusion about the air war in the Pacific, stating: "Control of the air was essential to the success of every major military operation."[4]

The successful use of the atomic bomb at both Hiroshima and Nagasaki, however, made the conclusions of the *United States Strategic Bombing Survey* irrelevant in the eyes of many U.S. Army Air Forces (USAAF) leaders and civilian defense analysts. They wondered if air superiority was now a seemingly impossible mission since the two cities had each been destroyed by an atomic bomb dropped from a lone B-29 Superfortress that had penetrated deep into enemy territory without fighter escort. Yet the strategists ignored the reality that the atomic missions would have failed without American control of the air over Japan. At the time, total war with the Soviet Union seemed imminent, and although the United States and Great Britain shared a monopoly on atomic technology in the immediate postwar period, the military and civilian leadership wisely assumed that the Soviet Union would eventually develop atomic weapons.

If at some future date the Soviet Union sent waves of long-range bombers toward the continental United States, aircraft from the Air Defense Command would probably intercept and destroy most of the enemy aircraft before they reached their targets. A few Soviet bombers, however, would probably survive long enough to destroy their targets in the United States. The resulting devastation would far surpass the cost of building an effective air defense system.

This fatalistic attitude toward air superiority could be seen as early as August 22, 1945—a mere eight days after the war in the Pacific ended. On that day, Maj. Gen. Lauris Norstad, the USAAF's chief of plans, cautioned that the atomic bomb might have made tactical airpower "as old fashioned as the Maginot Line."[5] A month after the Soviets exploded their first atomic bomb in September, 1949, Lt. Col. Harry M. Pike of the air force's Air Command and Staff College faculty wrote: "If our enemies send over great numbers of aircraft carrying enough atomic bomb-type weapons to attain a goodly part of their strategic objective's [*sic*] and if our air defense system is capable of destroying only about ten percent of their planes and probably a lesser percentage of their missiles, is the expenditure of such an enormous sum—probably billions of dollars—for an air defense system feasible and acceptable?"[6]

Eight months after Lieutenant Colonel Pike's article was published, TAC issued a Request for Proposal for a supersonic interceptor. For the next twenty years, no aircraft designed primarily around the air-superiority mission would be built for the air force for two reasons: Soviet bombers would not have fighter escorts, and those bombers had to be intercepted and destroyed long before they reached the North American continent. Convair won the design competition, and eventually a total of 875 F-102A Delta Daggers were built. The F-102A was followed by the Lockheed F-104 Starfighter, the F-106 Delta Dart, and finally the McDonnell F-4 Phantom II. Throughout the 1950s and 1960s, the air force emphasized interceptors and surface-to-air missile systems over fighter aircraft because the war planners considered a nuclear war with the Soviet Union as the primary threat to American security. By the time America entered the war in Vietnam, all of its pure air-superiority aircraft had either been retired or given to the Air National Guard.

The other three types of tactical aircraft in the air force inventory during this period (the F-100 Super Sabre, F-101 Voodoo, and F-105 Thunderchief) were developed for interdiction bombing with tactical nuclear weapons. Although the F-100A Super Sabre was a fighter aircraft, the D model of the "Hun" was designed solely for the air-to-ground mission. American foreign policy and intense intraservice competition between the Tactical and Strategic Air Commands for increased funding levels compelled TAC to concentrate on delivering nuclear weapons.

The National Security Act of 1947 created an independent air force on September 18, 1947. As Caroline Ziemke writes, "Independence marked the end of nearly three decades of struggle for the air forces, but it marked just the beginning of TAC's struggle for survival."[7] The Tactical Air Command, established a year and a half earlier, received major command status in the new U.S. Air Force, but many of the service's senior leaders, especially Gen. Curtis E. LeMay, resented that fact. To LeMay, Gen. Hoyt S. Vandenberg, and others, TAC's major command status "was a reminder of its former subordinate status [to the army] and a threat to its future independence. As long as TAC remained a major command, the Army had an influence over one-third of the USAF mission."[8] The air force's senior leaders did little to hide their feelings of contempt for tactical aviation from Congress and from the American public. In a speech before the House Armed Services Committee in 1952, Rep. Sterling Cole (R-New York), a navy supporter, boldly remarked: "aviation problems of the Army have been the stepchild of the Air Force."[9] When Air Force Chief of Staff Hoyt Vandenberg retired in 1953, he "warned against impairing the basic security of the United States by cutting Strategic Air Command and Air Defense Command." Reporting on the budget battles in Congress, *Aviation Week* further stated that "Some top USAF brass are willing to scrap Tactical Air Command, troop carrier outfits and cut MATS to the bone to save SAC and ADC."[10] Finally, in May, 1956, Secretary of Defense Charles E. Wilson told the House Appropriations Committee: "If you left it up to General LeMay, you would spend a great deal more for these B-52s, and we would have about four plants making them instead of two. He would not bother with very many fighters. That would be his slant on it."[11]

Few were surprised when, on November 18, 1948, TAC became a subordinate unit of the Continental Air Command. A week after TAC lost its major command status, *New York Times* military analyst Hanson W. Baldwin cited the importance of tactical aviation in World War II and then warned: "There has been, indeed, too much concentration on strategic air power at the expense of close-support aviation. Tactical air power must not be subordinated."[12] The Tactical Air Command, however, remained a subordinate command even after the infamous "Revolt of the Admirals" in October, 1949.

The "revolt" began when several influential admirals, including Arthur W. Radford and Thomas C. Kincaid, protested the cancellation of the navy's first supercarrier, the USS *United States*. The navy also accused the air force of improper procurement practices in its Convair B-36 Peacemaker program. Representative Carl Vinson (D-Georgia), chairman of the House Armed Services Committee, conducted a series of public hearings on the B-36 program and other related matters. During the hearings, the navy argued that the air force had severely damaged its tactical airpower capabilities by allocating the bulk of its share of the defense budget to purchasing and operating the B-36.

The air force responded to the navy's allegations by citing the current JCS war plans, which directed the air force to first provide for "the retaliatory atomic offensive," then to provide for "the air defense of the United States," and lastly to provide "air support of ground troops."[13] In short, the air force told the House Armed Services Committee that it was simply following orders. Nevertheless, the Tactical Air Command would not be restored to major command status until the Korean War was five months old.

The traditionalists who continued to promote tactical aviation during the New Look days were criticized for their apparent ignorance and lack of vision. Senator Joseph O'Mahoney (D-Wyoming), chairman of the Appropriations Subcommittee on the Armed Services, remarked that the "problem will be one of finding methods of cutting military expenditures for traditional operations in the Army and Navy which do not appear necessary in light of modern scientific advances which have given us an atomic weapon."[14] *Newsweek* Washington correspondent Ernest K. Lindley argued: "The proper balance among our own armed forces will, or should, shift also with the development of new weapons. Are our professional military leaders fully alive to the potentialities of new weapons? For several years after the war, there was a tendency in the Navy, and to some extent in the Army, to underestimate the destructive power of atomic weapons."[15]

From the end of World War II until North Korea invaded South Korea on June 25, 1950, the United States depended on atomic superiority to deter communist aggression and expansion around the world. No nation would dare risk atomic destruction for the chance to conquer new territory, or so the military and the State Department believed. The Korean War thus came as a complete surprise to the United States, as did President Truman's decision not to use atomic weapons on the peninsula even after the Chinese massively intervened in the conflict. Clearly, the Strategic Air Command had failed to prevent the war, and thus the Tactical Air Command "took on the status of David in Korea when the SAC Goliath proved too lumbering—indeed, irrelevant—to meet the challenge of limited war."[16]

Years of fiscal subordination to SAC had taken a toll, however. During the first critical year of the Korean War, TAC lacked sufficient assets to wage a conventional air war in Korea and was forced to recall many Air National Guard units. Both the air force and the navy relied heavily on World War II–era fighters such as the F-51 Mustang and F4U Corsair to provide close air support since jet aircraft, pilots, and ground crews were in limited supply. In describing the Far East Air Forces during the first year of the war, historian Walter J. Boyne states: "All in all, it was a great World War II air force with which to prevent World War III. Fortunately, although the equipment was obsolete and the mission dictated by the war was not the one they had trained for, the aircrews were both highly skilled and adaptable. More important, they were ready to fight."[17] Colonel William M. Reid, a member of the Air War College Evaluation Staff in the mid-1950s, brilliantly summarized the problem in an article published in the *Air University Quarterly Review.* According to Reid: "In 1950, when the United States faced in Korea the new and unexpected problem of 'limited' or peripheral war, tactical air power was not in a position to cope adequately with this new wrinkle in communist aggression. Its capability was hamstrung by previous rigid restrictions of the military budget and by a shell of complacency that had settled over the hard-learned lessons of World War II."[18]

The experiences of the Korean War and the French defeat at Dien Bien Phu in 1954 created in some people a renewed interest in tactical airpower. In an article entitled "Learning the Lessons of Korea," retired Air Force Chief of Staff Gen. Carl A. Spaatz wrote: "No time should be wasted in building the air defense of the United States and its allies. We shall need the most and the best fighter planes for home protection against enemy air raids, to escort bombers on aggressive missions, and to win control of the air over the ground fronts."[19] The Ninth Air Force commander, Brig. Gen. James Ferguson wrote: "It hardly needs to be mentioned that the first and most important lesson [from both World War II and Korea] was that control of the air is a prerequisite for any large-scale military operation. . . . Without the constant attention that we had paid to the airfields in North Korea, we might have taken off one morning long after the disappearance of a North Korean Air Force to find a superior air force [from the the Peoples' Republic of China] operating within a few miles of our front lines."[20]

Voicing similar concerns, Hanson W. Baldwin asked his readers to consider nuclear weapons not as mutually exclusive ordnance types for the U.S. military. He also urged them to remember that "The Dienbienphu battle proves once again—if such proof is needed—that atomic and hydrogen arms are of little or minor use in inhibiting or waging small wars, limited wars, or struggles such as those in Indo-China, Malaya, street-fighting in Trieste, Israeli-Arabian border clashes, the recent Greek guerrilla war, etc."[21]

Unfortunately for the Tactical Air Command, those who agreed with Spaatz and Baldwin were in the minority. Strategic Air Command's nuclear bombers and intercontinental ballistic missiles with nuclear warheads maintained their prominent position in the air force, and SAC continued to receive a disproportionate share of the defense budget. Commenting on the overall performance of the air force in the Korean War, Walter Boyne suggests that the emphasis on nuclear weapons hindered the execution of the air war in Korea. Boyne further observes that "Praise would have been heightened and criticism diminished if it had been widely appreciated that the Air Force was fighting its war with aging equipment, inadequate logistics, and a shortage of manpower. And it is rarely acknowledged that the USAF . . . had a priority higher even than the combat in Korea. This was the creation of a nuclear deterrent force so powerful that it would succeed in preventing a third world war."[22]

Business Week magazine illustrated the emphasis given to both the Strategic and Air Defense Commands when it listed the ten highest-grossing defense contractors in the months following the armistice in Korea. The Boeing Airplane Company, manufacturer of the B-47 Stratojet and B-52 Stratofortress, had ascended from sixth place to second place and had received $4.40 billion in new orders. The Consolidated Vultee Aircraft Corporation, maker of the B-36 Peacemaker and F-102 Delta Dagger, had climbed from sixteenth to eighth place with $2.07 billion in new contracts. The remaining eight firms had demonstrated little or no change in ranking. The magazine editors remarked that the "added workload at Boeing and Consolidated Vultee shows just where added funds for air defense are going: long-range bombers, all-weather interceptors, [and] guided missiles."[23]

Caroline Ziemke asserts that President Eisenhower and the air force "seemed to have observed a different war [in Korea] than TAC and the other services, or at the very least had derived an entirely different set of lessons."[24] Furthermore, "the apparent connection between his veiled threat to use nuclear weapons against North Korea and the armistice of 1953 convinced Eisenhower that the U.S. nuclear deterrent could effectively contain communist expansion on all levels at a lower overall cost than maintaining a conventional deterrent."[25]

Eisenhower and SAC commander Gen. Curtis Lemay concluded that a large, strategic nuclear force could provide for the common defense of the nation and its allies while simultaneously permitting the reduction in the size of the army, navy, and non-SAC air force commands. To them, the Strategic Air Command's ability to protect the United States through threats of nuclear annihilation was the most cost-effective defense plan available. Thomas H. White, in a 1963 review of the military under the administration of Secretary of Defense Robert McNamara, noted: "It is significant that old-fashioned *battle-field war* is so much more expensive than new-fashioned *nuclear war* and growing more so. The Nuclear War Programs, now cut to $9.3 billion for 1964, can eliminate civilization from the globe and thus provide an all-time 'biggest bang for the buck.' The Conventional War Programs now cost more than twice as much—$20 billion in next year's proposed budget."[26]

Tables 1 through 4 present elements of the defense budget for

Table 1.
Total Obligational Authority in the Truman Administration (funds are shown in billions of dollars)

	1950	1951	1952	1953
Air Force	$5.42	$15.20	$22.37	$20.45
Navy	$4.35	$12.48	$16.22	$12.68
Army	$5.42	$19.58	$21.35	$15.22

Source: The Budget of the United States Government for the Fiscal Years Ending June 30, 1950–53.

Table 2.
Aircraft and Related Procurement Budget in the Truman Administration (funds are shown in billions of dollars)

	1950	1951	1952	1953
Air Force	$1.10	$7.29	$11.88	$12.68
Navy	$0.52	$2.86	$4.33	$3.91

Source: The Budget of the United States Government for the Fiscal Years Ending June 30, 1950–53.

Table 3.
Total Obligational Authority in the Eisenhower Administration (funds are shown in billions of dollars)

	1954	1955	1956	1957	1958	1959
Air Force	$15.66	$12.13	$15.51	$17.69	$17.73	$18.71
Navy	$12.91	$10.22	$9.64	$10.22	$10.50	$11.82
Army	$12.91	$7.76	$7.35	$7.67	$17.73	$9.38

Source: The Budget of the United States Government for the Fiscal Years Ending June 30, 1954–59.

Table 4.
Aircraft and Related Procurement Budget in the Eisenhower Administration (funds are shown in billions of dollars)

	1954	1955	1956	1957	1958	1959
Air Force	$3.49	$2.76	$5.54	$5.58	$5.86	$4.57
Navy	$1.37	$1.97	$2.01	$1.81	$2.01	$1.50

Source: The Budget of the United States Government for the Fiscal Years Ending June 30, 1954–59.

the decade of the 1950s.[27] Funds for waging the Korean War are not included in the tables, as they were not published in the federal budget. The following tables clearly show that the air force received a disproportionate amount of funding during both the Truman and Eisenhower administrations.

In an age of severe defense budget cutting and SAC preeminence, TAC commanding generals John K. Cannon (1951–54) and Otto P. Weyland (1954–59) knew that TAC's survival as a major command depended on its ability to deliver tactical nuclear weapons. In order to increase its share of funds in the New Look defense policy, TAC had to evolve into a miniature version of SAC.

By 1959, only a few people, such as Gen. Matthew B. Ridgway and Gen. Maxwell Taylor, openly opposed the idea of massive retaliation as America's primary military policy. General Weyland knew that TAC's share of the defense budget was a factor of its ability to wage tactical nuclear war, but to his credit, Weyland testified before Congress that "it is my personal view that our tactical air force structure is reduced right now to rock bottom and I personally consider that we are in a precarious or questionable position."[28] The air force, however, virtually ignored Ridgway, Taylor, and Weyland. In the month following Weyland's testimony before Congress, the senior editor of *Air Force Magazine* opined:

> There have been some witnesses in recent weeks who argue that our total kill capability is too great and there is not enough emphasis on the less-than-total capability. This approach does not give proper evaluation to the role played by tactical air.
>
> Effectiveness of the Tactical Air Command, like that of the ground forces in Europe, is dependent on the certainty that the Strategic Air Command stands in back of every military effort by the free world. For this reason nobody, not even TAC, will argue today that SAC should sacrifice to support any other kind of military strength. This goes for tactical air, the ground forces, the navy, and the Marines.[29]

The TAC thus abandoned the close air support and pure air-superiority missions primarily for financial reasons but also because they seemed to be at best questionable activities in the planners' most important war scenario: a nuclear war with the Soviet Union. Perhaps Ziemke best explains this difficult period: "By the late 1950s, the command perceived itself primarily as an extension of nuclear deterrence—a sort of massive retaliatory capability on the regional rather than global level. Other missions, especially air-ground and air-air operations, fell into neglect as TAC became an increasingly specialized strike command. Like Dorian Grey, TAC had sold its soul in exchange for vitality, and in Vietnam, the world got a look at its aged and decrepit conventional structure."[30]

By becoming a miniature version of SAC, TAC entered the air war in Vietnam with aircraft that were ill suited for aerial combat with the small, highly maneuverable MiG fighters. The following two chapters will provide an explanation of why TAC's aircraft were ideal interceptors and tactical nuclear bombers but inferior when used as air-superiority fighters and conventional fighter-bombers.

CHAPTER 2

Higher, Faster, Mediocre

AIR FORCE PILOT AND KOREAN WAR ACE Capt. Harold Fischer once remarked: "It was a constant wonder why a newer aircraft could be less effective than an existing one and still be put into production."[1] Although he was referring to the F-84 and the F-80, respectively, his statement applies equally well to the F-86 Sabre and its successor, the F-100 Super Sabre. During the Korean War, the F-86A/E/F Sabres ruled the skies over "MiG Alley," and the postwar F-86H Sabre was arguably one of the best air-superiority aircraft ever produced.

The F-100 Super Sabre, on the other hand, never quite matched the performance standards set by its famous predecessor. The New Look defense policy and intraservice air force politics led the engineers at North American Aviation (NAA) to create a fighter aircraft that was inferior in the air-superiority role. In comparison, the Soviet aircraft design bureau of Mikoyan-Gurevich (MiG) continued designing and producing lightweight, very maneuverable, cannon-armed fighter aircraft until the mid-1960s. Thus, the development of the F-100 symbolized the end of air-superiority aircraft in the active air force inventory until after the North Vietnamese MiGs challenged TAC for control of the air over Southeast Asia.

Before discussing the design features and performance characteristics of the various models of Sabres and MiGs, some basic principles of aerospace engineering should be explained. All of the following equations are taken directly from Prof. John D. Anderson, Jr.'s, *Introduction to Flight*. There are four fundamental forces that affect an airplane in flight: lift, weight, thrust, and drag. In level, unaccelerated flight, the wings of an airplane will generate enough upward force (lift) to exactly balance the downward pull of gravity (weight) upon the aircraft. The engine must develop enough power (thrust) to counter the resistance of the surrounding air to forward movement (drag).

Lift (L) is mathematically defined[2] as the product of the dynamic air pressure (q_∞, calculated as half of the free-stream air density (ρ) multiplied by the square of the aircraft velocity [V_∞]), the wing area (S), and the lift coefficient (CL, the ratio of the aerodynamic lifting force to the dynamic air pressure and wing area), or:

$$L = \frac{1}{2}\rho V_\infty^2 S C_L = q_\infty S C_L$$

Thus, the only practical way to increase lift is to accelerate and increase the dynamic air pressure, or to increase the wing area. Increased thrust, however, creates a corresponding increase in the drag force, which then decreases aircraft efficiency. Unfortunately, increased wing area also increases aircraft weight, structural complexity, and parasite drag. Thus, minimizing weight is critical for a successful design.

Weight also plays a major role in determining an airplane's maneuverability. An aircraft's turning rate depends on weight, wing area, airspeed, and centripetal forces. The basic equation[3] for the rate of turn (ω) is

$$\omega = \frac{g(n - 1)}{V_\infty}$$

In this equation, g is gravitational acceleration, n is defined as the load factor, or the ratio of the airplane's lift to its weight $\{n = (L/W)\}$, and V_∞ is the airspeed. Maximum turn rate (ω_{max}) is governed by the formula:[4]

$$\omega_{max} = g\sqrt{\frac{\rho_\infty C_{L,max} n_{max}}{2(w/s)}}$$

where ρ_∞ is the free-stream air density, $C_{L,max}$ is the maximum lift coefficient, n_{max} is the maximum load coefficient, W is the aircraft's weight, and S is the wing area. Dividing the aircraft's weight (W) by its wing area (S) results in a quantity called the wing loading, or the amount of weight that each square foot of wing must lift.

Turn rate is perhaps the most important quality in fighter design for both offensive and defensive situations. A superior turn rate "allows the attacker to match the turn rate of his adversary and establish lead for a gunshot against him. The attacker also needs a turn rate capability that will allow him to pull his nose onto the bandit, while remaining within 30 degrees aspect of his tail to employ the AIM-9P [Sidewinder infrared-guided missile]."[5] In defensive maneuvers, if the defending aircraft has a sufficient turn rate it will force the attacker to quit flying a lead pursuit course and commence flying a lagging pursuit course, thus denying the attacker an opportunity for a gun kill. An aircraft with an adequate turn rate can also defeat certain infrared-guided missiles by immediately turning onto a course perpendicular (ninety-degree aspect angle) to that of the missile.

The turning radius (R) of an airplane is also a factor of the aircraft's weight, airspeed, and centripetal forces. The governing equation for turning radius is:[6]

$$R = \frac{V_\infty^2}{g(n - 1)}$$

Minimum turn radius (R_{min}) is defined as:[7]

$$R_{min} = \frac{2}{\rho_\infty g C_{L,max}} \frac{W}{S}$$

Although the turn radius is important, the turn rate is vital for success in aerial combat. As air force fighter weapons instructor Pete Bonanni states, "A fighter with a superior turn rate can outmaneuver a fighter that has a poor turn rate but a tighter turn radius."[8] Maximum maneuverability occurs at the airspeed where both maximum turn rate and minimum turn radius are achieved. This is known as the corner velocity. At speeds above the corner velocity, the aircraft's turn rate begins to decrease and its turn radius rapidly increases.

A final concept to be presented is that of energy maneuverability. An aircraft in flight possess two kinds of energy: kinetic energy from the thrust of its engine and potential energy, which can become kinetic energy if altitude is converted into airspeed. Kinetic energy (E_k) is mathematically expressed as one-half of the object's mass multiplied by the square of the object's velocity, or:

$$E_k = \frac{1}{2mV^2}$$

Potential energy (U) can be numerically expressed as the object's mass multiplied by the earth's gravitational acceleration (g) and the object's height (h) above some reference point (usually mean sea level), or:

$$U = mgh$$

Combining the aircraft's kinetic and potential energy values yields the specific energy (E_S), or the total energy available to the airplane. By dividing the equation with the weight of the aircraft, the formula for specific energy becomes:[9]

$$E_S = \frac{h + V^2}{(2g)}$$

As the above equation illustrates, a maneuvering aircraft undergoes a change in its specific energy content. The rate of change in the specific energy value is known as the specific excess power (P_S). Physically speaking, specific excess power determines the aircraft's ability to climb or accelerate. Mathematically, P_S can be expressed as:[10]

$$P_S = \frac{(T - D)V}{W}$$

where T is the thrust, D is the total drag, W is the aircraft's weight, and V is the velocity of the aircraft. The above equation reveals that if the total drag exceeds the available thrust, the aircraft must either lose altitude or airspeed. Conversely, if the available thrust is greater than the total drag, the aircraft will be able to either climb or accelerate.

A revolution in military aviation occurred on July 25, 1944, when the world's first operational turbojet aircraft, the Messerchmitt Me-262 Schwalbe, attacked a propeller-driven Royal Air Force de Havilland Mosquito. Although the twin-engine German jet was nearly seventy miles per hour faster than any other Allied aircraft, Flt. Lt. A. E. Wall managed to successfully evade the jet by capitalizing on the Nazi pilot's mistakes.[11] The Me-262 could have been a most effective interceptor against Allied bomber formations had Adolf Hitler chosen to use it in that capacity, but he insisted that it be used as a fighter-bomber against Allied ground forces. The Me-262 obtained only limited success as a tactical bomber, but it proved to be a brilliant interceptor. As Gen. Carl Spaatz testified, "These deadly German fighters could make Allied bombing attacks impossible in the near future."[12] The British and the Americans scrambled to develop a turbojet-powered fighter to counter the Me-262 but met with little initial success.

North American Aviation, designer of the legendary P-51 Mustang, submitted a proposal to the War Department on May 18, 1944, for a straight, laminar-flow-winged fighter aircraft powered by a J35-GE axial flow turbojet. The USAAF, however, was not pleased with the performance of the new jet aircraft designated the XP-86: its top speed of only 575 miles per hour failed to meet USAAF specifications. Fortunately, the army had captured several German aeronautical research documents that solved the XP-86 performance problems.

At transonic speeds (Mach 0.8 to Mach 1.2), the drag force increases substantially because of shock waves forming at the minimum pressure point on the airfoil and from airflow separation behind the shock wave. This phenomenon is known as wave drag, and a combination of wave drag and low thrust limited the XP-86 and other early jet aircraft to speeds of less than 600 miles per hour. The German aerodynamicists, however, discovered that the detrimental effects of wave drag could be delayed to a higher Mach number by sweeping the wings backward. North American Aviation engineers evaluated the captured German data and decided to add thirty-five degrees of sweep to the XP-86 wing and vertical stabilizer. The horizontal stabilizers were swept back approximately thirty degrees.[13]

Swept-wing aircraft traditionally have poor low-speed handling characteristics, but NAA engineers lessened the effects of this control problem by incorporating another captured German innovation—leading edge slats—into the XP-86 wing. Basically, the leading edge of the wing slides forward and down when the airplane is flying at low speeds. This changes the camber of the wing and provides a much greater lifting force. The leading edge slats open and retract automatically by means of a pressure sensor. Imparting a slight twist to the Sabre's wingtips also improved its low-speed stability. This "wash out" effect serves to retard the forward motion of the wing's center of pressure as a stall approaches. A sudden, forward movement in the wing's center of pressure results in a violent nose-up pitching motion. Swept wings are particularly vulnerable to this instability problem, which can be fatal to an inattentive pilot.

Ailerons covered 14 percent of the total XP-86 wing area, and the massive ailerons with their large deflection angles generated extremely large stick forces at high speeds. Thus, roll controls were hydraulically boosted to ease the pilot's workload. According to Robert McLarren in *Aviation Week,* "This combination of slots [or slats] and ample aileron control gives the F-86 surprisingly gentle stall and landing characteristics."[14] North American's chief engineer, Ray Rice, wrote: "Handling and stalling characteristics at low speeds were comparable to those of the best straight wing airplanes, the only difference being a higher angle of attack for take-off and landings."[15]

The USAAF ordered three prototype aircraft in November of 1945, and the first XP-86 was completed on 8 August 1947. Like its predecessor, the P-51 Mustang, the XP-86 featured a number of radical innovations. North American engineers reduced the aircraft's weight by using a single sheet of aluminum with tapered thickness on the wings. Sheet thickness increased proportionally to span-wise aerodynamic loading. Prior to the XP-86, aircraft wings were strengthened through the use of overlapping aluminum sheets of varying thickness, which added unnecessary weight. The inboard section of the wings also used a double skin structure separated by hat-sections instead of a conventional rib and stringer arrangement. This feature reduced weight and structural complexity while also making the wing less susceptible to aeroelastic divergence than a conventional wing structure. Basically, aeroelastic divergence occurs when the lower pressure air flowing over the wingtips (wingtip vortices) imparts a torsional moment on the wings that actually twists the shape of the wingtip and reduces aileron effectiveness.

Furthermore, the XP-86 speed brakes could be operated at any airspeed, and the airplane was designed for easy maintenance. The nose panel sections used interlocking hinges for quick and easy access to control cables and other equipment, and the fuselage was divided into two sections just aft of the wing trailing edge. The first jet engines required frequent repair, and NAA engineers designed the Sabre so that four mechanics could change an engine in thirty minutes. The first flight of the XP-86 occurred on October 1, 1947, and an XP-86 with a more-powerful J47-GE-3 engine allowed NAA test pilot George Welch to break the sound barrier on April 25, 1948. Pleased with the greatly improved performance, the air force ordered the F-86A into production.

The F-86A was a slightly modified XP-86. The belly speed brake was deleted and the side fuselage speed brakes opened toward the rear. The F-86A also featured an armored windscreen, six .50-caliber machine guns, and provisions for an underwing pylon with an external fuel tank or bombs. More importantly, the A model Sabre used the J47-GE-1 engine that produced fifty-two hundred pounds of static thrust (lbst). Despite a few problems with the external fuel tank release, gun bolts, and fuel control system, pilots raved about the Sabre. For example, Robert A. "Bob" Hoover, considered by many to be the world's best pilot, readily states: "My favorite [airplane] is the F-86 . . . of all the airplanes I've flown, it's the most honest bird in the bunch. When I say 'honest', I mean predictable . . . forgiving."[16]

The F-86E was a major improvement in the air-superiority line of Sabres.[17] The E model was an F-86A with three significant changes. The new F-86E used a more reliable J47-GE-13 engine, and an optically ground, flat, armored windscreen protected the pilot. Most importantly, the E-model Sabre featured a one-piece horizontal "stabilator." Wave drag at transonic speeds limits elevator effectiveness, and NAA solved this problem by replacing the horizontal stabilizer and elevator with a single control surface known as a stabilator. The stabilator greatly improved the Sabre's performance at transonic speeds.

Combat pilots in Korea and NAA test pilot George Welch suggested improvements to the F-86E that led to the development of F-86F. Because of its lower weight, the MiG-15 Fagot enjoyed superior maneuverability compared to the F-86A/E at high altitudes. Welch proposed extending the Sabre wing-root chord by six inches and adding three inches to each wingtip. The leading edge slats were removed to reduce weight and because they sometimes opened unevenly. The asymmetrical lift created by improper slat deployment induced a rolling moment that could cause the Sabre to snap roll into a spin.[18] North American engineers mounted a thirty-five-inch-long by five-inch-high fence to each wing for better span-wise flow control. The F-86F also used a more powerful J47-GE-27 engine (rated at 5,910 lbst) and an A-4 radar-ranging gun sight. The primary and redundant hydraulic lines were separated to prevent a single projectile from a MiG-15 cannon from destroying both lines, and protective armor plating was installed around the horizontal stabilator's actuator.[19]

Air force pilots used the new "6–3 leading edge" wing to great advantage during the last few months of the Korean War. During June, 1953, F-86 pilots downed 77 MiG-15 Fagots, probably destroyed another 11, and damaged 41 MiGs without losing a single Sabre in the process.[20] *Aviation Week* reported that "A hitherto-secret improvement in the wing design of North American Aviation's F-86

Sabre jets was the undisclosed 'gimmick' that boosted the U.S. victory margin in MiG Alley during the closing months of the Korean War. . . . [One group reported that the] 'turning advantage was readily apparent. No tracking problems were encountered. One MiG-15 was easily tracked at extremely high G and high Mach airspeeds.'"[21]

Although it still could not maneuver as well as the MiG-15 at high altitudes, pilots loved the sturdy Sabre. "Just before one particular brawl, I counted 150 MiGs in three formations converging on our two squadrons of twelve Sabres each," wrote Maj. Douglas K. Evans. "Only in the F-86 could we have made it through such odds without becoming Thanksgiving turkeys. . . . Only occasionally does a fighter come along that can produce such intense loyalty, one that gives the pilot a feeling he can meet any challenge with confidence."[22]

During the Korean War, Sabre pilots flew a total of 87,717 missions, downed 792 MiG-15 Fagots as well as twenty-two other communist aircraft. A total of seventy-eight Sabres were lost in Korea, or a 10.15:1 MiG-to-Sabre kill ratio. Moreover, each of the thirty-nine air force pilots who earned the title of ace in Korea flew the F-86.[23] Sabre pilots also enjoyed other qualities that the MiG-15 lacked: self-sealing fuel tanks, armored cockpit, radar gun sight, and a superior diving capability. Major William Wescott, who became one of those thirty-nine aces after only a month of combat, reported: "The dive characteristics of the F-86 were used to great advantage against the MiG. The F-86 was able to attain a higher Mach number in a dive. In addition, the MiG could not pull as much G as the F-86 at the higher Mach number, while pulling more G, the F-86 could convert airspeed to altitude and regain maneuvering superiority over the MiG. . . . Most MiG pilots wouldn't even try to follow the F-86 in a dive from high altitude."[24]

Except for the nose, multiple wing fences, and tail assembly, the MiG-15 Fagot bore a strong resemblance to the F-86 Sabre. Both designs borrowed heavily from captured German technology. With its single 37-mm and two 23-mm cannons, the MiG-15 was better armed than the Sabre. Its empty weight was also a ton lighter than the F-86A. This gave the MiG-15 a lower wing loading, a superior climb rate (thirty thousand feet in 3.8 minutes), and a higher ceiling (55,100 feet).[25]

Like all of the early jets, the Fagot had its share of design and production problems. Poor workmanship and quality control practices often limited the MiG's performance, and cockpit visibility suffered from frequent fogging and frosting. The pilot's climate control system was inadequate at best. Worst of all, the MiG-15 had terrible stall characteristics—including no stall warning system. The MiG-15 could turn faster than any F-86 model, but inferior construction and a lightweight wing and vertical stabilizer severely restricted its maneuverability in the transonic region.[26] Brigadier General Charles E. Yeager, who test flew a MiG-15 after the Korean War, stated: "Flying the MiG is the most demanding situation I have ever faced. It's a quirky airplane that's killed a lot of its pilots. . . . It has problems—oscillating, pitching up unexpectedly, fatal spins, no stall warning, lousy pressurization, and a particular warning from Lieutenant Ho [Kim-Sok] not to turn on the emergency fuel pump. That could blow the rear off the airplane; the North Koreans lost four or five MiGs that way."[27]

Most MiG tactics involved diving upon the American aircraft from behind, making one firing pass, and then quickly climbing back to altitudes that the heavier Sabre could not reach—a hit-and-run or "shoot-and-scoot" strategy.[28] Superior pilot training and a well-designed fighter, however, gave the air force unquestioned control of the skies over MiG Alley.

In the final days of the Korean War, both NAA and the Mikoyan-Gurevich design bureau substantially refined their respective aircraft. The North American F-86H became the best air-superiority fighter in the air force for the next two decades, and the MiG-17 went on to serve with distinction in North Vietnam. H-model Sabres used a J73-GE-3D turbojet engine that produced 8,920 lbst—3,010 lbst more than the J47-GE-27 turbojet that powered the F-86F to victory in Korea. The new Sabre received an improved wing, too. The F-40 wing used on the F-86H was a "6–3 leading edge" wing with the leading edge slats reinstalled and an additional one-foot extension at the wingtip. Longer wings and leading edge slats significantly improved the Sabre's high altitude and high speed flying characteristics. The F-86H also received more firepower: the six .50-caliber machine guns were replaced by four rapid-firing 20-mm cannons. Although the 37-mm and 23-mm cannons used on both the MiG-15 and Mig-17 were more powerful than the Sabre's 20-mm cannons, their slower rate of fire proved to be a disadvantage. The F-86H remained active in the Air National Guard until 1970.[29]

Brigadier General Robin Olds, commander of the 8th TFW in Vietnam and four-time MiG killer, described the MiG-17 as "a vicious . . . vicious little beast."[30] Moreover, "'The MiGs were a [expletive] severe threat! They were a worrisome thing, and time after time, you were in there fighting for your life, not with the intent of shooting down a MiG, but just getting yourself and whoever was with you, home in one piece!'"[31]

The MiG-17 Fresco A, which was basically a refined MiG-15, used an improved VK-1A turbojet engine, but featured a thinner wing with rounded wingtips. The inboard leading edge of the MiG-17 wing was swept back forty-nine degrees and the outboard leading edge was swept back 45.5 degrees. The MiG-17 thus was often referred to as the "Sickle" wing. The Fresco's fuselage was four feet longer than the Fagot's, and it also had larger tail surfaces. Lastly, the MiG-17 wing included a third wing fence to better control span-wise flow at high angles of attack. All of these refinements succeeded in giving the MiG-17 better handling characteristics than the MiG-15 in transonic flight.[32]

Because its maneuvering ability was still relatively poor at high Mach numbers, many observers mistakenly believed that the MiG-17 ailerons were not hydraulically boosted, but the Fresco control surfaces were assisted by the BU-1U hydraulic boost system. The emphasis on saving weight, however, led to poor control response at high speeds. The lightweight wing design suffered from aeroelastic divergence, which led to aileron flutter. To help reduce the onset of flutter, the designers added a small weight to each wingtip.[33]

Despite its flaws, which included terrible pilot visibility, the MiG-17 Fresco became one of the most successful fighters of all time. Twenty different European, Asian, African, and Middle Eastern nations flew the MiG-17, and it is still operational with a few air forces in developing nations. A MiG-17F Fresco C, with an afterburning VK-1F turbojet producing 7,452 lbst and carrying two AA-2 Atoll infrared homing missiles and three cannons, proved to be a most deadly weapon in the hands of a skilled pilot. The MiG-17 certainly posed a very real threat to the sophisticated air force and navy supersonic interceptors, interdiction bombers, and subsonic attack aircraft in the air war over North Vietnam. MiG-17 pilots downed seventeen of the sixty-six American aircraft lost (25.75 percent) in air-to-air combat over Southeast Asia.[34]

The successor to the F-86 series was the F-100 Super Sabre. At the unveiling of the new F-100A Super Sabre, test pilot George Welch executed three consecutive low-level supersonic passes over the crowd. According to *Aviation Week,* "The first public demonstration of the new North American aircraft left onlookers gasping and children crying."[35] The new Super Sabre may have made a frightening first impression on the spectators, but it was not impressive as an air-superiority fighter. Originally designed as a supersonic all-weather fighter, the air force asked the NAA to redesign the F-100 for the daytime interceptor mission. Thus, supersonic airspeed at cruise altitude and a high rate of climb replaced maneuverability as the primary design goals for the F-100. To appease army concerns that TAC had ignored the close air support role, the air force also asked the NAA to develop a ground attack version of the Super Sabre. North American responded to this request with the F-100C/D aircraft, which included a centerline bomb rack for tactical nuclear weapons and underwing pylon mounts for conventional bombs.[36]

The F-100 was the first production aircraft to achieve sustained supersonic flight.[37] North American Aviation boldly proclaimed the Super Sabre the "greatest advance in aviation since the advent of jet power plants."[38] In some ways, the F-100 was a technological wonder: The Super Sabre was the first production aircraft to use large quantities of titanium, which led to many new tooling and production processes, and the F-100 generated many advances in supersonic aerodynamic theory.[39] The F-100 Super Sabre performed much better than the MiG-17 at transonic and supersonic speeds because of a radical design innovation by NAA engineers. The F-100 wing incorporated inboard ailerons, which greatly reduced aeroelastic divergence. Furthermore, the F-100 wing consisted of a front spar, four vertical stiffeners that extended to nearly 70 percent of the wingspan, a rear spar, and tapered skin, which combined to make for an extremely strong wing.[40]

The sonic booms produced by the Super Sabre created much consternation for those who lived near air bases, but the air force asked irate residents to "learn to live with the noise of engines and shockwaves as a reasonable sacrifice in the interests of peace and security."[41] *Flight* magazine also suggested that the "shocks could in wartime be used for such varied tasks as damaging enemy aircraft on the ground; making housing unusable in very cold weather by breaking all of the windows; rubbing out vehicle tracks in loose earth; or simply for smashing delicate technical equipment."[42]

However, that same edition of *Flight* unknowingly illustrated the fundamental problem with the F-100 as an air-to-air fighter:

> They [F-100C pilots at Bitburg Air Base, Germany] have had dog-fights with Canadian Sabre 6s [F-86F with a 7,275 lbst engine], Sabre 5s, R.A.F. Hunters and Meteors and they delight in their speed advantage over all of them. The Meteor is comparatively so slow, and can turn so tightly, that the F-100 *rarely gets time to fire at it before it disappears astern* [italics added]; the best stratagem for the F-100 is to stand off a few miles and then charge. The Sabre 6 gives quite a lot of trouble, both because of its great power and its good turning circle; but the F-100 can usually manoeuver to a good hitting position by using its tremendous power and speed capabilities. As for vertical-plane capability, it can out yo-yo the Sabre. The Hunter, too, gives the F-100 a good deal of trouble. The pilots particularly remarked on a very tight turn.[43]

The F-100D Super Sabre, with its forty-five degree swept-back wings and J57-P-21A engine producing 11,700 pounds thrust (16,950 with afterburner engaged), served as a very respectable interdiction bomber. The D-model Super Sabre, however, "was developed as a dedicated fighter-bomber, with no attempt to call it an 'air-superiority fighter with fighter-bomber capabilities.'"[44] According to aviation historian Bert Kinzey: "The legacy of the light, simple, maneuverable, air-superiority fighter that came from the P-51 and F-86 was now completely gone. . . . The design had evolved from one end of the spectrum to the other."[45] Unfortunately, the Super Sabre replaced the F-86 as the air force's primary fighter aircraft. By attempting to placate the army and the Air Defense Command, TAC found itself without a true air-superiority fighter throughout the late 1950s and 1960s.

As early as 1952—three years before the air force received its first F-100A—TAC realized that the newly developed F-100 was not a suitable air-to-air fighter aircraft. The Air Research and Development Command began evaluating designs for a new, lightweight daytime fighter to supplement the F-100 in 1952. The proposed fighter would have a combat weight of ten thousand pounds, fly at Mach 1.1 at an altitude of thirty-five thousand feet, climb at ten thousand feet per minute, and have a combat range of four hundred nautical miles. The air force Directorate of Requirements stated that, "In the period 1955–1957, the F-100 will be the USAF first line Day Fighter.

This aircraft will be replaced by one of better performance which is expected to be operational in the period 1957–1959. The top speeds of these aircraft will range from Mach 1.3 to Mach 1.8, and it is expected that their overall performance will be adequate to assure defeat in aerial combat of the best aircraft any enemy might produce."[46] Unfortunately, that aircraft was never built.

The Soviets replaced the MiG-17 with the supersonic MiG-19 Farmer. The MiG-19 carried two RD-9B afterburning turbojet engines and still weighed more than a ton less than the F-100A and nearly three tons less than the F-100D. However, the two dissimilar airplanes shared a common problem: They were both extremely difficult to control in low-speed flight. The MiG-19 also was plagued by maintenance and design problems that contributed to scores of operational losses. Regardless, a well-maintained MiG-19 flown by a skilled pilot was a most effective weapon system in air-to-air combat.[47]

CHAPTER 3

Unprepared by Design

Aeronautical engineering is one of the most challenging and, to the general public, one of the least understood engineering disciplines. All airplanes, regardless of their type, are designed around a series of performance compromises or "design trade-offs." For example, an airliner sacrifices maneuverability for stability. Cargo aircraft exchange high airspeeds for long range and a large volume of usable space. To be successful, an airplane must be designed for a specific mission, and to deviate from that mission is to court failure. The phrase "multirole airplane" is truly misleading.

Among other things, a well-designed fighter aircraft should have moderate wing loading—between sixty and seventy-five pounds per square foot (psf), and a high thrust-to-weight ratio. Aircraft engines from the Vietnam era produced combat thrust-to-weight ratios ranging from 0.75:1 for the F-105 Thunderchief to 0.87:1 for the F-4 Phantom II (in full afterburner). Advances in material technologies and turbojet engine design allow modern fighter aircraft, such as the F-15 Eagle and F-16 Falcon, to have thrust-to-weight ratios of equal to or greater than 1:1. Thrust-to-weight ratio governs an aircraft's acceleration and climbing performance. An aircraft with a 1:1 thrust-to-weight ratio can maintain vertical flight. If the thrust-to-weight ratio exceeds 1:1, the aircraft can accelerate in vertical flight.[1]

The ability to operate in the vertical plane can sometimes mean the difference between victory or death in fighter combat, as in the case of an encounter between an F-4 Phantom and a MiG-17. The MiG-17 had a vastly superior turning rate and could outmaneuver the Phantom in the horizontal plane, but the Phantom had a much greater thrust-to-weight ratio and could outperform the MiG in the vertical plane. One of the two American ace pilots of the Vietnam War, Lt. Randy Cunningham, a navy pilot, remarked: "Very seldom did U.S. fighter pilots find a MiG that fought in the vertical. The enemy liked to fight in the horizontal for the most part, or just to run if he didn't have the advantage."[2]

Brigadier General Robin Olds, with four North Vietnamese MiGs to his credit, agreed with Lieutenant Cunningham when he said:

> It's all well and good to advertise that the F-4 would go Mach two and a little bit, or that the F-105 is the fastest thing down low that was ever built. But you are not able to use the capabilities with those bomb loads on board. . . . You are going pretty fast, but not as fast as the airplane is capable of under other conditions or circumstances. You are going at a speed where the MiG-17, as old as it [is], just may be the best. You are flying right in his speed range, so he can close with you, and once he closes with you, look out! Because he is so light, his turn capability is just fantastic! You can't possibly turn an F-4 with a MiG-17. So even though the F-4 is a marvelous air-to-air combat aircraft, it was no match for the MiG-17 if you tried to fight the way the MiGs fight. If you tried to fight in the classical, World War II sense of a dogfight, you just couldn't do it.[3]

Fighter pilots demand an excellent field of view from the cockpit—preferably one that approaches 270 degrees. The most vulnerable point of attack is from the aircraft's rear, where both the pilot and the aircraft radar are often blind. Despite a very sophisticated early-warning and ground-control intercept radar network, most American MiG kills in Vietnam occurred when the enemy pilot had little or no idea that he was about to be attacked.[4] The same, unfortunately, was often true for American pilots.

Because of their unique mission requirements and extremely high cost, fighter aircraft must be built to survive the harsh environment of modern aerial combat. Aircraft exposed to hostile fire, whether it is from the air or from the ground, must be able to absorb minor damage to critical systems and remain in the air. For example, the pilot and all vital systems, such as the hydraulic, fuel, and flight-control systems, need protective armor plating. Primary and redundant fuel, hydraulic, and flight-control systems should be separated and spaced reasonably far apart to prevent fatal damage to the whole system should shrapnel or an antiaircraft artillery shell strike the aircraft. Furthermore, the aircraft systems should be easy to repair and maintain. This design feature assumes critical importance should the aircraft be rapidly deployed to a remote forward air base. Lastly, a fighter aircraft should present the smallest optical, electronic, and thermal signature possible because "you can't fight what you can't see."[5]

The Tactical Air Command entered the war in Vietnam with two principal types of tactical aircraft in its inventory: interdiction bombers and interceptors. The only true air-superiority fighter in the American arsenal was the navy's F8 Crusader, whose pilots proudly declared themselves "The Last of the Gunfighters."[6] In the air force's war over North Vietnam, the McDonnell F-4 Phantom II served primarily in the air-to-air fighter role, and the Republic F-105 Thunderchief performed admirably in the air-to-ground mission.

The other principal TAC aircraft used in Southeast Asia included the North American F-100D/F Super Sabre, the Lockheed F-104 Starfighter, the McDonnell F-101 Voodoo, and the Convair F-102 Delta Dagger.[7] Most of these aircraft served as interceptors. An interceptor is designed to become airborne as quickly as possible, fly to altitudes between forty and sixty thousand feet at supersonic speeds, then locate and destroy incoming enemy bombers. Speed is an essential quality for interceptors: the enemy bombers must be destroyed before their nuclear cargo can be delivered. Interceptor maneuverability is sacrificed for two reasons. One is to reduce wave drag at supersonic speeds. To achieve this, an airplane needs small, thin wings. The F-104, commonly referred to as the "missile with a man in it," provides a good example of this design philosophy.

The 20,640-pound (combat weight) F-104G Starfighter boasted a wingspan of twenty-one feet nine inches and a wing area of 191.6 square feet. The short, stubby wings gave the F-104G an unbelievable wing-loading value of 107.7 psf. Granted that the F-104G could climb to forty-eight thousand feet in one minute, cruise at 510 miles-per-hour, and fly 1,146 miles-per-hour (Mach 1.74) at fifty thousand feet, it simply could not turn without devouring several square miles of sky.[8]

Three squadrons of Starfighters served in Southeast Asia from 1965 to 1968. Although F-104s provided top cover for the F-4 Phantoms on the legendary Operation Bolo, the Starfighter was used primarily as a fighter escort for the EC-121 Warning Star aircraft.[9] The three external ordnance fittings and internal 20-mm cannon also allowed the F-104 to be used in the close air support role, particularly in Laos. In its three years of action over Southeast Asia, however, the Starfighter never engaged a North Vietnamese MiG.

Mission requirements provide a second reason for designing interceptors with marginal maneuverability. Strategic bombers fly along level, steady courses as they plod toward their targets. Since heavy bombers cannot perform evasive maneuvers, interceptor pilots do not need an agile platform from which to fire their weapons.

During the war, the North Vietnamese Air Force bomber fleet consisted of only a few obsolete IL-28 Beagles, and thus the majority of air force interceptors (both the F-104 and the F-106) remained either in Europe or in the continental United States. The F-101 Voodoo, however, served with distinction in the photoreconnaissance (RF-101C) role until it was replaced by the RF-4C.

The F-102 Delta Dagger saw limited service in Southeast Asia. The Delta Dagger was an ideal interceptor for its time: it could cruise at Mach 1.5 at high altitudes, and it was very stable. Unfortunately, it also had many faults when used as a fighter. It lacked an internal cannon, was subsonic at lower altitudes, and its early-generation turbojet engines accelerated slowly.[10] Delta-winged aircraft have very high turning rates, but the high turn rate also creates a significant drag penalty that greatly reduces airspeed. The engines used in the F-102 simply could not accelerate fast enough to overcome the drag penalty imposed by the turn. In the aircraft's only air-to-air engagement of the war, two F-102s from the 509th Fighter-Intercept Squadron encountered two MiG-21s on February 3, 1968. One of the MiGs destroyed a Delta Dagger with an Atoll infrared-guided missile.[11] Former F-102 pilot Kenneth R. Lundquist noted that the "lack of overhead visibility made dogfighting difficult, if not impossible. We would have given anything for a gun and a clear vision canopy like the one later fitted to the F-106A. Unfortunately, the Air Force was in its rocket and missile period, and it took a war to show them that they were wrong."[12]

The F-105 Thunderchief carried the burden of the air force's air-to-ground war in North Vietnam from August 5, 1964, until October 6, 1970, and one can argue that the F-105 is as symbolic to the Vietnam War as the B-17 Flying Fortress was to World War II.[13] The Thunderchief, better known as the "Thud," flew a total of 157,895 combat and combat support sorties over Southeast Asia, and 84,950 of those missions (53.8 percent) were to the most heavily defended targets in North Vietnam. Thunderchief pilots suffered higher total combat losses per thousand sorties flown than any other fixed-wing aircraft that participated in the Vietnam War. Nearly 60 percent of all F-105s available for combat in Southeast Asia were destroyed.[14]

The Thunderchief was designed in late 1952 to deliver tactical nuclear weapons from European bases at supersonic speeds and at very low altitudes. Republic engineers gave the F-105 two unique features: the world's first internal bomb bay for a fighter aircraft, and plenty of weight. Alexander Kartveli, designer of the legendary P-47 Thunderbolt and the F-84 Thunderjet series, incorporated an internal weapons bay into the F-105 for either the MK-28 (EX and RE) or MK-43 tactical nuclear bombs. The interior weapons bay held either the aforementioned nuclear weapons or a specially designed 390-gallon fuel tank and was never modified to accept conventional bombs.

The Thunderchief became the heaviest single-engine aircraft ever built, with a maximum takeoff weight of 52,546 pounds and a typical combat weight of 33,841 pounds (F-105D). Pilots jokingly referred to the plane's manufacturer as "Republic Iron and Steel Works." The F-105 was also nicknamed the "Squat Bomber." Pilots quipped that the F-105 was so heavy that "all you had to do was find a tank, taxi over to him, and suck up the gear"—letting the weight of the aircraft crush the tank. Furthermore, the new F-105 suffered from its share of development problems.

The very sophisticated R-14 Search and Ranging Radar was initially prone to "gross errors in the terrain avoidance mode of operation" and proved difficult to keep in calibration.[15] In 1959, the Thunderchief required 150 hours of maintenance for every hour of flight time, and in 1964, the Thunderchief was the most expensive "Century Series" aircraft to operate, costing $718 per flight hour.[16] When the D model Thunderchiefs were removed from combat in the fall of 1970, Maj. Gen. Louis T. Seith remarked: "The F-105 is a heavy duty fighter bomber, and while it has made a substantial contribution to the air war, it is not as suitable for interdiction and close support missions as are other aircraft which are far less expensive to operate."[17]

Lastly, the early F-105s seemed especially prone to engine fires. After several aircraft were lost, engineers learned that the fuel pumps were developing cracks because of the high operating temperatures. Volatile fumes and fuel were being pumped into the aft section of the engine, and the engine would explode once enough vapor had accumulated. A series of ram-air vents in the tail section solved the problem, but not before the Thunderchief's reputation was tarnished. Pilots called the airplane "Republic's Triple Threat Weapon: Bomb-'em, strafe-'em and fall on 'em."[18]

The Thunderchief design incorporated a small wing (maximum wingspan: thirty-four feet eleven inches; wing area: 385 square feet) swept back at a forty-five degree angle. Using the Ground Support IV mission profile specifications (581 rounds of 20-mm ammunition for the M61 Vulcan cannon, six M-117 bombs at 750 pounds each on the centerline multiple ejector racks, and two M-117 bombs on the outboard pylons), an F-105D had a takeoff weight of 48,976 pounds. This gave the F-105 an extremely high wing loading value of 135.3 psf and very poor maneuverability.[19]

A flight of Thunderchiefs in the Ground Support IV configuration (typical interdiction load) could not engage the North Vietnamese MiGs without first jettisoning their external ordnance. The Air Force Historical Research Agency, in a postwar analysis of aerial combat in Vietnam noted: "Of the 3,938 strike sorties flown during September-December 1966, only 107 sorties—or 2.72 percent—jettisoned ordnance as a result of MIG interceptions. On the other hand, of the 192 strike aircraft actually engaged by MIGs, 107 (or 55.73 percent) jettisoned their ordnance. This rather clearly demonstrated that the MIGs reduced the effort of U.S. strikes on those days when they were committed."[20]

The single Pratt & Whitney J75-P-19W engine powering the F-105 generated 17,200 lbst and 26,500 lbst with the afterburner engaged. This gave the Thunderchief a thrust-to-weight ratio of 0.508 without the afterburner, and 0.783 (F-105D combat weight using the Ground Support IV mission specifications) with the afterburner engaged. The F-4D, by comparison, used twin General Electric J79-GE-15 engines that produced a combat thrust-to-weight ratio of 0.5311 (without afterburner) and 0.8767 (afterburner engaged). The Phantom's lower wing loading (typically about 73.17 psf), greater thrust-to-weight ratio, and high cruising airspeed made it an acceptable fighter escort for the Thunderchief.[21]

The men who flew the F-105 over North Vietnam loved its rugged construction and its ability to outrun any enemy aircraft at low altitudes (after the F-105 had released its bomb load), but they also had some noteworthy criticisms of the airplane. Lieutenant General Charles A. Horner, who flew forty-eight bombing missions in the F-

105D and another seventy missions in the F-105G Wild Weasel, commented: "If I ever was going against ground fire and I had my choice of any airplane, even now I would take an F-105. Because it was so rugged—you could have a wing blown off and it would keep on going. But it wouldn't turn worth a damn. For air-to-air combat, it would be the last airplane I would take."[22]

General Horner's statement referred to an actual event: An F-105 Wild Weasel lost several feet of one wingtip to an SA-2 missile while on a mission west of Hanoi. The Thunderchief continued flying, although the asymmetrical lift created a rolling moment and an electrical fire developed in the cockpit. As the crew "corkscrewed" toward the relative safety of the Tonkin Gulf, a North Vietnamese antiaircraft battery shot several feet from the other wingtip, which then corrected the rolling moment. The seriously damaged aircraft remained in the air long enough for the crew to safely eject over the ocean, where they were promptly rescued by American forces.[23]

Under the subheading "Sturdy Aircraft," *Aviation Week and Space Technology* reported two even more remarkable stories of the Thunderchief's ruggedness:

> In one instance, an F-105D was hit at 87 different places by fragments from an exploding SA-2, and the pilot still managed to refuel from a KC-135 and return to a friendly air base. Damage included a double break in a fuselage frame, loss of the ventral fin and engine gang drain plus the top of the vertical fin and rudder assembly. The pilot was also wounded in the left hand and leg.
>
> In another, a pilot managed to fly 500 mi. back to his home base after his aircraft had been hit in the inboard pylon section of the right wing by an 85-mm. anti-aircraft shell. The shell detonated and ripped away all of the structure within a 4-ft.-long area.[24]

"No aircraft ever earned more complete devotion from its pilots than did the F-105," boasted Capt. Don Carson.[25] Moreover, the former F-105 pilot noted: "In spite of the heavy wing loading and inability to turn well, the F-105 did a creditable job of downing MiGs in air-to-air battles. A total of twenty-nine MiGs was [*sic*] downed by F-105s during the war . . . not bad for an aircraft whose mission was to deliver bombs."[26] Captain Carson's figures do not, however, provide an accurate image of the air war over Vietnam. Officially, the

F-105 downed twenty-seven and one-half MiGs, but the communist pilots downed twenty-one F-105s.[27] The Thunderchief thus earned an exchange rate of 1.31:1 with the MiGs—the second-worst record of any American fighter aircraft in the war.

Colonel Jack Broughton, the former vice-commander of the 355th TFW at Takhli Royal Thai Air Base, extolled the F-105's ability to "go like a dingbat on the deck."[28] He also harshly condemned its extremely poor maneuverability:

> It seems like every hassle we get wrapped up in pits us against lightweight and highly maneuverable interceptors who always have the ability to outturn us and disengage us at will. Perhaps some day we will produce a machine capable of turning with them on even terms. . . . In the meantime, while we insist on building large supersonic flatirons whose pilots must avoid the basic aerial maneuver of trying to outturn the enemy, I would strongly suggest serious thought toward a rearward firing missile as that seems to be where the MiGs show up most of the time—on our behinds.[29]

Colonel Broughton continued his discussion on TAC's overall poor performance by crediting any successes to Vietnamese ineptitude. Broughton, who had flown fighters in Korea and led the air force's aerial demonstration team known as the Thunderbirds, emphatically stated: "I have yet to see any general indication that the MiG drivers we have faced thus far are using the maximum skill or technical capability available to them . . . they could murder us if they did the job properly."[30]

Unofficial air force statements about the F-105's agility disputed the reports of combat pilots. *Air Force Magazine,* for example, boasted: "The F-105 was fitted to the air-ground mission with the hope of getting the best possible air-to-air performance as a dividend."[31] As the records show, the "hope" for the "best possible air-to-air performance" was in vain. Air force historian Mark Clodfelter wrote concerning the F-105: "Air planners considered the plane's inability to dogfight irrelevant. They contended that nuclear raids on enemy airfields combined with air-superiority missions would guarantee the Thunderchief a safe environment."[32]

In October, 1966, J. S. Butz, Jr., *Air Force Magazine*'s technical editor, reported: "The F-105 is the best available ground-attack aircraft, and its design has been completely vindicated in the eyes of most pilots and combat commanders. Very few of them would like to see the aircraft change in any basic way or want to remove any system to make it simpler."[33] Once again, the *Air Force Magazine* staff apparently failed to consult with those who flew the F-105 in harm's way. For example, both F-105 pilots and F-4E Phantom II pilots loudly complained about the number of switches on the instrument panel that had to be toggled when changing between offensive weapons systems.

To change from one weapons system to another, the pilot removed his left hand from the throttle, placed it on the lower left side of the instrument panel, and reset four switches. To change from an air-to-air missile system to the internal 20-mm cannon, the pilot again removed his left hand from the throttle, placed it on the lower left side of the instrument panel, and turned a wafer switch. While resetting the arming switches, the Thunderchief or E-model Phantom pilot also had to both fly his airplane and keep the rolling and maneuvering MiG within the appropriate weapon's firing parameters. "There were an intolerable number of switches and buttons that had to be pushed or pulled to get the system from one armament mode to the other," Colonel Broughton explained.[34] Commander John B. Nichols, who flew four tours in Southeast Asia, remarked: "Switchology also was a factor. Launching a [radar-guided AIM-7] Sparrow involved a fairly complex procedure of radar tracking and locking-on, coordinating between the pilot and backseater, and setting the switches in the correct sequence. The system was fine for engaging distant bombers, but rather cumbersome in a dogfight."[35]

The most critical design problem of the F-105, however, lay in the location of its hydraulic lines. Both the primary and redundant hydraulic lines were placed in a side-by-side arrangement along the fuselage. One round from an antiaircraft weapon near either hydraulic line would usually destroy both, thus rendering the aircraft uncontrollable. Concerning the manufacturer's failure to design for combat survivability, Broughton lamented: "This was the curse of the Thud. . . . She was prone to loss of control when the hydraulic system took even the smallest of hits. There is just no way to steer her once the fluid goes out, and I can tell you from bitter experience that you can lose two of the three hydraulic systems that run all of your flight controls by the time you realize you have been hit. Once they have a vent they are gone."[36]

The Thunderchief's hydraulic system troubles were not corrected until the summer of 1967, when it was too late for scores of aircraft and their crews. Republic engineers developed an interim solution to the problem: a mechanical slab, driven by the nose ram-air turbine, would lock the horizontal stabilator into a neutral position before the hydraulic system failed completely. The pilot could make minimal control inputs through the electrically powered aileron trim switch and by adjusting the throttle setting. Although the pilot lacked sufficient control to safely land the airplane, the modification allowed him the possibility of ejecting over friendly territory. Republic also developed the Thunderstick 2 modification package, which included self-sealing fuel tanks, a bomb-bay fire extinguisher system, and an independent pitch-control system that used a differential flap to maintain roll control through the trim switch and an auxiliary control column.[37] The Thunderstick 2 modification would theoretically permit the pilot to return to his home air base. "If we had had such modification at the start of this war we would most probably have at least one hundred pilots who are now statistics," said Colonel Broughton.[38]

Ten years after the war, an *Air University Review* titled "Thunderchief" noted: "The F-105 was designed . . . under the assumption that it would have to face defenses consisting mostly of large, sophisticated surface-to-air missiles (SAMs). Since a hit by a large missile warhead was presumed to mean an automatic kill, the F-105 was built with little emphasis on system redundancy and resistance to battle damage."[39]

Thus, the war planners lowered the F-105 mission height to extremely low altitudes, well below the two-thousand-foot minimum effective altitude for an SA-2 surface-to-air missile. Unfortunately, lowering the mission altitude exposed the aircraft to small-arms fire, automatic weapons, and antiaircraft artillery (AAA). The war planners later defended this strategy by noting that the Soviet border was simply too large to surround with a practical air-defense system. The tacticians believed that the F-105 could exploit the large gaps in AAA placement on its way into the Soviet Union. Likewise, the Thunderchief pilot could simply engage the afterburner and easily speed away from any MiG pilot brave enough to press an attack.

Vietnam revealed the many fallacies of this argument. A skillful Thunderchief driver could probably avoid an enemy's border defenses, but what about the layers of AAA and SAMs protecting the target? For example, *Aviation Week and Space Technology* described the air defenses around Hanoi and Haiphong as follows: "Defensive rings of

Soviet-built SA-2 Guideline surface-to-air missiles (SAMs) and conventional anti-aircraft weapons around the two cities were even stronger than suspected. Consecutive defensive rings surround the two cities, with those closest to the city centers having the greater number of weapons. Standard configuration calls for a ring of SAMs supported by radar-guided 85-mm. and 57-mm. anti-aircraft guns plus visually-trained 37-mm. weapons."[40]

Penetrating enemy airspace seemed easy to the air force pilots. Surviving over the target long enough to deliver ordnance sometimes proved difficult. During the month of October 1967, sixteen Thunderchiefs were shot down, and fourteen more F-105s were lost in November.[41] Reflecting upon those two terrible months in the fall of 1967, an extraordinarily pessimistic Korean War veteran and F-105 pilot stated: "I'm not a fatalist. But, I had simply made up my mind that I couldn't make it. . . . The weather saved us. It's as simple as that. The most optimistic man in the world is an F-105 Jock who gives up smoking because he's afraid of cancer."[42]

Likewise, once an aircraft is committed to dropping a bomb onto a target, it must maintain a steady course. If the pilot takes evasive action, bombing accuracy will suffer accordingly. MiG pilots knew this as well as the F-105 pilots did, and they exploited this fact by attacking from behind as the Thunderchiefs either commenced or completed their bombing runs. One of the founders of the Naval Fighter Weapons School, Cmdr. John C. Smith, vividly described one such incident: "'They were coming right at us. The [expletive] had launched just as we were leaving. They had timed us so many times on our bombing runs that they knew how long we were going to be there, and when we were going out. They launched to come up to our tails just as we were leaving, and we'd never know what hit us.'"[43] The MiGs thus minimized their exposure to AAA while simultaneously attacking the F-105s at their most vulnerable moment. The MiGs, the multitude of enemy air defenses, lack of maneuverability, poorly planned hydraulic system layout, and yes, the rules of engagement, combined to exact a heavy toll from the F-105 fleet.

McDonnell Aircraft Corporation created the venerable Phantom II in response to a 1952 U.S. Navy Bureau of Aeronautics request for a carrier-based supersonic interceptor. The Vought F8 Crusader won the contract, but McDonnell believed in its design and adapted it to the role of a carrier-based tactical bomber. For armament, the proposed aircraft contained four 20-mm internal cannons and could carry a variety of ordnance from eleven pylons mounted along the fuselage and under the wings. In 1955, the navy asked McDonnell to reconfigure the airplane into a long-range, high-altitude, all-weather interceptor, armed only with air-to-air missiles. Thrilled with the flight test results, the navy accepted the new F4A Phantom II in 1961.

Secretary of Defense Robert S. McNamara insisted on instituting cost-containing measures throughout the Department of Defense, and weapons procurement was no exception. Placing budgetary concerns ahead of specific mission requirements, the secretary insisted that both the air force and the navy purchase the same aircraft types. To placate the powerful Secretary, the air force agreed to evaluate the F4. During the evaluation process, the air force flew the F4 against its new F-106A interceptor. The air force leadership was astonished to see the Phantom outperform the vaunted F-106 in virtually every category. After a few minor modifications, the air force then ordered 583 F-4C Phantoms.[44]

McDonnell's design proved to be one of the great airplanes of all time, but the Phantom suffered from three major problems, two of which stemmed from American faith in strategic nuclear deterrence. Since the navy had originally requested a supersonic interceptor, McDonnell engineers minimized the possibility that the Phantom might someday be engaged in a tight dogfight with small, agile MiGs. Hence, the F-4 suffered from terrible visibility in both the forward and aft directions. The long nose and large windscreen frame combined to greatly restrict forward visibility. A Phantom pilot could check the critical area behind his aircraft only by raising the nose of the airplane and rolling it to one side. Concerning the Phantom's poor visibility, U.S. Marine Corps pilot John Trotti remarked, "On a scale of one to ten, I would give the Phantom a three. . . . It was of little consolation then to know that the designers of the next generation of fighters realized that good visibility was more important than an extra tenth of mach [*sic*] number or ten miles of radar range."[45] Since the days of Baron von Richthofen and Eddie Rickenbacker, most fighter attacks have been from the rear of the aircraft where an unwary pilot had no idea that he was about to be attacked. Pilots and engineers later worked to correct this problem with a series of rearward-facing mirrors, but mirrors can never substitute for the naked eye.[46] Poor visibility was and will always be an unforgivable sin in fighter aircraft design.

The two General Electric J79 turbojet engines powering the

Phantom produced a very visible plume of coal-black smoke, which unfortunately revealed the aircraft to both enemy gunners and opposing MiG pilots. Colonel Phil Handley remarked that he "once read the debriefing report of a MiG-21 pilot who commented that he had been briefed that the F-4 smoked badly, but that the first time he actually saw one in flight he thought it was on fire."[47]

When the air force originally purchased the F-4, General Electric offered a modification to the J79 engine that would virtually eliminate the smoke. The "smokeless" option cost only a few thousand dollars per engine, but the air force rejected the proposal on its $2.4 million airplane (F-4E) since it was "not an operational requirement."[48] But those who flew the Phantom in combat disagreed with the air force's assessment. Phantom crewmen soon discovered that the smoke vanished once the afterburner was engaged, so pilots flying through a high-threat environment would often set the throttle to the minimum afterburner position. However, this procedure effectively doubled the rate of fuel consumption and was therefore used only when truly necessary.

The six hundred-gallon centerline external fuel tank created another problem for Phantom pilots in combat situations. Jet fuel weighs approximately six and one-half pounds per gallon, so a full centerline tank weighs about two tons. The weight of the external fuel tank limited the Phantom's maneuverability, and the drag force created by the tank greatly reduced the maximum airspeed. Thus, F-4 pilots needed to promptly jettison the centerline tank and the two 370-gallon wing-mounted external fuel tanks upon receiving word from the airborne control agencies (Disco or College Eye), sea based controllers (Red Crown), or from the land-based intelligence agency (Tea Ball) that MiGs were in the area.

Unfortunately, the centerline fuel tank tended to roll along the bottom of the fuselage and strike one of the horizontal stabilizers when released at high speeds.[49] Despite the fact that a Phantom's cornering velocity is around 450 knots (calibrated airspeed), the F-4 technical orders (flight manual) specified that the centerline tanks be released at 375 knots calibrated airspeed during straight and level flight below 35,000 feet and at 425 knots calibrated airspeed above 35,000 feet, which meant that the pilot may have needed to lose over 75 knots of airspeed just when he needed to maximize his available energy to engage the MiGs. Concerning the centerline fuel tank, Brig. Gen. Robin Olds stated: "We found by the hard way that in order to get rid of that tank, you had to slow down to 300 knots indicated or below, fly straight and level, get perfectly trimmed up, and then punch it off and just hope that it didn't hit you. Anything other than this, I would guarantee you a great big rip in the belly of your airplane, sometimes three and four feet long which, of course, increased your maintenance problem somewhat."[50]

The air force's official review of aerial combat in Southeast Asia, known as Project Red Baron III, suggested that in the future, "external-store jettison limits for combat aircraft should be consistent with the speeds and maneuvering conditions of the missions which the particular aircraft is expected to perform."[51]

Pilots use ultra-high frequency (UHF) radios to communicate with ground controllers, airborne controllers, and with other aircraft. The UHF radio is vital to the success of a mission. Unfortunately, radio failure plagued the Phantom throughout the Vietnam War. The F-4's UHF radio was often unreliable, and the Project Red Baron III report noted, "The F-4 radio, which contributed to the loss of numerous US aircraft during Rolling Thunder, continued to be a problem in Linebacker."[52]

The Project Red Baron III report concluded that future fighter aircraft needed to be equipped with at least two separate UHF radios with an increased channel capacity to help prevent frequency saturation.[53] The location of the radio aggravated the problem. The radio was located underneath the rear ejection seat, which meant that the maintenance crew had to first disarm the ejection seat, remove the entire ejection seat assembly, remove the radio, and then repair, test, and replace the radio. Then the ejection seat assembly had to be reinstalled and rearmed—a time-consuming, labor-intensive, difficult, and dangerous procedure.

Faith in advanced missile technology and the belief that America's greatest threat came from Soviet strategic nuclear bombers created another major problem for the Phantom: no internal gun. The F-105 contained a six-barreled, 20-mm Gatling gun, and the F-100 held four 20-mm cannons. The F-4C and F-4D Phantom aircraft, however, were unarmed once their complement of air-to-air missiles had been launched. In contrast, the MiG-17 carried one 37-mm cannon and two 23-mm cannons.[54] The MiG-19S Farmer C contained three 30-mm cannons with seventy rounds of ammunition per gun, and the MiG-21F Fishbed C typically carried a single 30-mm cannon, sixty rounds of ammunition, and two Atoll missiles.[55]

The MiG-21PF and MiG-21PFV Fishbed D, along with the MiG-21PFM Fishbed F, carried only two Atolls or two AA-1 Alkali radar-guided missiles, but North Vietnamese pilots generally preferred the older, slower, cannon-armed MiG-17 Fresco C to the newer, more sophisticated, missile-equipped MiG-21.[56] The Soviet aircraft engineers from the Mikoyan-Gurevich design bureau rarely failed to design their tactical aircraft without first considering the needs of traditional air combat.

As mentioned in the introduction, the air force did carry the AIM-4 Falcon, but it was not an effective weapon. Never one to mince words, General Olds stated that the AIM-4 was

> no good. It was just no good. In assuming that everything worked just as advertised, which it seldom did, the missile only had 2¾ pounds of unsophisticated explosive in it, and it had a contact fuse so the missile had to hit what you're aiming at for this little firecracker to go off . . . go bang. Now those [AIM-4 missiles] that were fired met all the perameters [*sic*] and performed as they were supposed to perform. We had too many times, time and time again, the missile would pass right through the hottest part of the exhaust plume of the MIG-17 which is about a 12 foot miss and that and, you know, 5¢ will get you a bad cup of coffee. Secondly, its launch perameters were much too tight, not as advertised, but as changed once they got the things to the theater. . . . And it turned out that if you were at 10,000 feet in a 4 G turn, the minimum altitude at which that weapon was any good was 10,500 feet. The maximum range of the little [expletive] was 12,000 feet or something on that order. So it's just no good. I mean, maybe, if one of the MIGs would be very accommodating and sort of hold still for you out here, you know, that would be fine.[57]

The air force relied primarily upon either the radar-guided AIM-7 Sparrow or the infrared (heat-seeking) AIM-9 Sidewinder missiles for success in aerial combat. During the entire Vietnam War, however, the AIM-7 achieved an overall kill ratio of only 9.15 percent. A total of just 56 of the 612 Sparrow missiles fired in aerial combat actually acquired and destroyed their target.[58] The AIM-9 fared only slightly better, achieving a 24.45 percent kill ratio. Out of 454 Sidewinder missiles launched against MiGs, 111 of the missiles destroyed the enemy aircraft.[59] Before 1965, military planners and aeronautical engineers believed that aircraft guns were obsolete in the age of radar-guided and infrared missiles. Since the strategists also assumed that the next war would involve a supersonic penetration into the Soviet Union, tactical fighter-bombers would not need guns as they delivered their nuclear ordnance. The heavy cannon and ammunition thus could be deleted to increase the aircraft's range and nuclear payload capacity. Likewise, air force interceptors would engage Soviet bombers at great distances where guns would be useless.

Not everyone believed that aircraft cannons were obsolete. William Kennedy wrote in 1962, "The hope that . . . air-to-air missiles would be able to take up where the interceptor left off was an illusion from the start . . . the best of the air-to-air missiles do not extend the range of the fighter beyond VFR [Visual Flight Rules] contact."[60] Major General Frederick C. Blesse, the sixth-ranking jet ace in Korea, author of "No Guts, No Glory" (the standard air force manual on fighter tactics in the 1950s), and a veteran of 380 combat missions over Southeast Asia in the F-4, considered the decision to remove the guns from the Phantom a disaster. "I had felt for years we went in the wrong direction in the Air Force when we decided guns no longer were necessary," General Blesse observed. ". . . My experience in Korea seemed to tell me otherwise. Missiles didn't always work, they had limiting parameters under which they couldn't be fired, they were ballistic (no guidance) for several hundred feet after launch, they didn't arm immediately, and in general, left a great deal to be desired."[61] General Blesse argued that the air-to-air missile and the gun were complementary weapons systems, not mutually exclusive armaments. General Olds concurred: "No fighter should be built without a gun in it. That's basic and then anything else you can add is just Jim Dandy with me."[62]

Seventh Air Force commander Gen. William W. Momyer offered several reasons why air-to-air missiles did not perform well in the Vietnam War. "The numbers don't fairly represent the kill rates of the missiles, however, for it was a standard tactic to fire missiles as a [MiG] deterrent, even though the pilot knew that he was out of range," he stated.[63] Concerning the AIM-7 Sparrow, General Momyer noted that the missile was intended to acquire and destroy targets far beyond the pilot's visual range. In Vietnam, though, American pilots encountered a political requirement to visually confirm their target before attacking. Political considerations thus limited the missile's operational envelope. Lastly, General Momyer remarked that the Sparrow was designed to acquire and destroy Soviet strategic bombers flying a predictable, steady course. An aircraft engaged in aerial combat moves continuously through space in an unpredictable, unruly manner. Therefore, design limitations greatly reduced the effectiveness of the AIM-7.

After the war, the navy launched its own investigation into the Sparrow program. The final report found the following four main problems with radar-guided missiles in Southeast Asia. Pilots tended to launch all of their Sparrows at once at a single target (a technique known as "ripple fire"), which created a statistical problem. The dream of almost every fighter pilot is to someday attack and defeat an enemy aircraft, but the vast majority of fighter pilots never even see an enemy aircraft, much less have the opportunity to duel with one. When presented with the rare opportunity to destroy an enemy aircraft, an aggressive fighter pilot will often ripple fire his missiles to better his chances of destroying the enemy. But using up four missiles per target destroys the statistical overall missile effectiveness.

As discussed earlier, the complex missile firing procedure requiring that four switches be set in sequence also limited AIM-7 accuracy. The report also determined that the dynamic nature of modern aerial combat further limited the Sparrow's effectiveness. Any weapons system has both a minimum and maximum firing range, known as the weapons envelope. The minimum and maximum effective ranges vary with the angular difference between the course heading of the aircraft employing the weapon and the course heading of the target aircraft ("angle-off"), the distance between the two aircraft, and with the angle between the tail of the target aircraft and the aircraft firing the weapon ("aspect ratio"). Most dogfights occur at transonic speeds, so the size and shape of the weapons envelope constantly changes.

A fighter pilot must fly his airplane, keep the enemy pilot within the radar sight while also tracking other hostile and friendly aircraft, and compensate for a changing weapons envelope in order to properly employ the Sparrow missile. Randy Cunningham, who scored all five of his aerial victories with the heat-seeking AIM-9, noted: "Of the 204 [navy] Sparrows which functioned properly, 55 percent were fired outside required launch zones. Of 245 Sidewinders, half were not fired within lethal parameters."[64] Even with its relatively restrictive weapons envelope, however, most fighter pilots liked the Sidewinder as a long-range weapon. Concerning the AIM-9 Sidewinder, General Olds commented that it was a "wonderful little weapon."[65] The general praised the missile because "it was reliable, it was simple to maintain, it only took about five minutes to hang that thing on an airplane and check it out. . . . It had a sophisticated warhead with . . . [a] fragmentation pattern that was excellent and it had a proximity fuse so I was personally quite happy with the Sidewinder."[66]

Finally, the complex circuitry of the missile itself bred failure. The delicate electronics were jolted by ordnance handlers on the ground, subjected to intense vibration and mechanical stresses while attached to the airplane, and exposed to both extreme humidity and to rapid changes in temperature. The above factors combined to create a dismal success rate for the air-to-air missiles of that era.[67] General Olds agreed with the navy's assessment, but added that "in the main the Sparrow was a lovely sort of stand-off weapon. Its problem was that it really required a lot of [system maintenance] . . . we had to continually keep the radar's [*sic*] peaked and when you're flying a bunch of airplanes—those that are available to you—an average of 85 to 90 and sometimes more air frame hours—hours of utilization, per bird, per month—this turnaround rate is pretty high and you just don't have time to peak up all the little systems with all the exactness that it takes to make this system work well."[68]

General Blesse solved one of the Phantom's armament problems in the spring of 1967. The general, then a lieutenant colonel, extensively rewired the airplane and mounted an SUU-16 gun pod onto the centerline hard point of an F-4C. The SUU-16 is a General Electric M61A1 Vulcan cannon—a ram-air powered, six-barreled, 20-mm Gatling gun that fires up to sixty-six hundred rounds per minute. The gun pod worked perfectly during flight testing, but two other problems had to be resolved before the experiment could be tested in combat. First, an air-to-air gun sight for the SUU-16 had to be developed, and second, the 366th TFW had to obtain official permission to try the gun in combat. After much trial and error, the pilots learned that, "if you put the [radar] pipper on the target, then moved it forward about twice as far as you thought necessary before you began to fire, you would overlead the target. The procedure then was to begin firing as you gradually decreased your amount of lead. This would allow the enemy aircraft to fly through your very concentrated burst."[69]

Obtaining official permission proved equally difficult. General Blesse flew to Saigon to brief General Momyer on the experiment.

General Olds, who was also present at the briefing, rejected the idea, but General Momyer said, "I think you have a hole in your head, but go ahead with your gun project and keep me informed."[70]

The experiment proved to be a resounding success. In its initial encounter with North Vietnamese MiGs on May 14, 1967, the cannon-carrying Phantoms from the 366th TFW downed three MiG-17s. General Blesse summarized the engagement in the wing's daily operational report that went directly to General Momyer. The text of his report, which is destined to become a classic of military literature, reads as follows: "We engaged enemy aircraft in the Hanoi area, shooting down three without the loss of any F-4s. One was destroyed with missiles, an AIM-7 that missed and an AIM-9 heat-seeker that hit. That kill cost the U.S. government $46,000. The other two aircraft were destroyed using the 20mm cannon—226 rounds in one case and 110 rounds in the other. Those two kills cost the U.S. government $1,130 and $550, respectively. As a result of today's action, it is my personal opinion that there will be two pilot's meetings in the theater tonight—one in Hanoi and the other at the 8th TFW at Ubon [General Old's headquarters]."[71]

Other squadrons soon adopted the gun pod for their F-4Cs and Ds, and eight more MiGs were downed with the SUU-16 before the end of the war.

The air force, to its credit, listened to the complaints of the Phantom crews when it wrote the specifications for the next F-4 variant. The F-4E was originally developed around the very sophisticated Coherent-On-Receive pulse-Doppler System (CORDS) radar, but the development problems inherent with such an advanced system could not be overcome in a timely manner and the system was canceled. The cancellation created a controversy within the service over which radar to use in the improved Phantom: the Westinghouse AN/APQ-120 or the APG-59/AWG-10. Used in the navy's F4J, the APG-59/AWG-10 radar was superior to the AN/APQ-120 in the air-to-air mode, but it was also significantly larger.

After much debate, the air force chose the smaller, less effective AN/APQ-120 radar for one reason: it facilitated the installation of an internal cannon. The new F-4E Phantom was armed with an M61A1 cannon (the same cannon used in the SUU-16 gun pod) mounted in a faring underneath the smaller nose radome. Ammunition for the gun (640 rounds maximum) was housed in a drum located behind the radome bulkhead.[72] The determined efforts of Generals Blesse, Olds, et al. had finally paid off. As an added benefit, another fuel tank was added to the aft fuselage to offset the weight of the gun and ammunition in the nose. By the end of U.S. involvement in Southeast Asia, the F-4E's internal cannon had accounted for seven enemy aircraft, including the MiG-19 shot down by Major Handley.

The Phantom's worst problem, however, lay in its tendency to depart from controlled flight at high angles of attack (the angle between the relative wind and the chord line of the wing). Below a 12-degree angle of attack, a Phantom pilot rolls the aircraft using only the aileron/spoiler controls. Between a 12- and 16-degree angle of attack, the pilot should use a combination of aileron/spoiler and rudder for roll control. Above a 16-degree angle of attack, the F-4 pilot should use only the rudder to roll the airplane. If the pilot attempts to roll the aircraft with aileron/spoiler controls at a high angle of attack, the Phantom will usually cease functioning as an airplane and quickly become a spinning, thirty-eight-thousand-pound aluminum brick.

This potentially catastrophic phenomena known as "departure" results from the adverse yaw effect. Basically, ailerons control lateral flight by changing the camber of the airfoil, which increases the lift force on one wing while simultaneously decreasing the lift force on the other. The airplane then compensates for the asymmetrical lift forces by rolling toward the wing with reduced lift. The Phantom, and many other modern high-speed aircraft, are not designed with true ailerons, but instead use a combination of ailerons and spoilers (flat plates on the top surface of the wing) for roll control.

For the purpose of illustration, imagine that a pilot is flying on a heading of 90 degrees (true east), and he wants to turn south and fly on a heading of 180 degrees. The pilot pulls the control column slightly back and pushes it toward the right while also adding right rudder. The left aileron simultaneously hinges downward, creating more lift on the left wing than on the right, while the spoiler on the right wing rises up and disturbs the airflow over the right wing. This decreases the lift and greatly increases the drag forces on the right wing.

At high angles of attack, the disturbed airflow, increased drag, and decreased lift force produced by the spoiler will combine to overcome the lift force from the deflected aileron. Under those conditions, the Phantom will immediately begin turning sideways because of the adverse yaw effect, and the disturbed airflow will then begin to rotate like a horizontal tornado. Soon the turbulent flow over the tail surfaces will render the horizontal stabilators and rudder surfaces completely ineffective, and the pilot will no longer be able to control the airplane. If the F-4 undergoes departure, and if the pilot has sufficient altitude, he can attempt to regain control by first centering the control column and then pushing it forward to hopefully reduce the angle of attack. Should this step fail, the pilot must then release the drag chute and hope that the drag from the parachute will force the airplane's nose into the relative wind. If this procedure also fails, the crew should eject when the Phantom falls below an altitude of ten thousand feet.

Unfortunately, departure usually occurs only when the F-4 is engaged in air-to-air combat. Using the rudder for roll control instead of the ailerons requires both a conscious effort and a substantial amount of self-discipline from a pilot who is preoccupied with obtaining a missile lock on the enemy aircraft, protecting his own aircraft from an unseen enemy, and generally trying to maintain situational awareness in an environment that is changing at nearly the speed of sound. Departure can, however, be used to a pilot's advantage. For example, if a pilot has an enemy attacking him at close range from the rear, he can force the opponent's aircraft to overshoot him by properly departing the aircraft. Although the aircraft will then possess very little maneuvering energy, it will at least defeat the initial attack and give the pilot a few more seconds to improve his desperate situation.

Learning how to prevent departure while controlling the aircraft at high angles of attack requires extensive practice. It must become an instinctive reaction for the pilot. The necessary training in departure avoidance and recovery, however, was often not permissible, as will be discussed in chapter 4. No one knows exactly how many air force, navy, and Marine Corps Phantoms were lost to departure, but the number approaches two hundred aircraft.[73] Aside from the cost in aircraft and weapons systems, one should also remember the fact that North Vietnamese MiGs shot down only thirty-nine Phantoms during eight years of war. Departure and insufficient pilot training proved to be a serious problem throughout the Phantom community.

Earl H. Tilford described the ideal air force tactical fighter as "one that could fly at the speed of sound, fight its way through enemy defenses, and then deliver a hefty bomb load."[74] As both the F-4 and the F-105 examples have illustrated, the "ideal tactical fighter" of the Vietnam era encountered great difficulties while serving in the air-superiority role. The ability to fly more than the speed of sound did not guarantee success in aerial combat. According to a postwar study by Everest Riccioni, "The vast majority of military operations and all heavy air combat maneuvering was done in the domain of speeds below 1.2 Mach."[75]

A common but often misunderstood saying in the fighter pilot community is that "Speed is life." Airspeed is indeed very important, but it is a combination of superior turn rate (in either the horizontal or vertical plane), experience combined with realistic training, and a knowledge of both your airplane's capabilities and those of your opponent that kills. By taking advantage of the Phantom's greater thrust-to-weight ratio, a well-trained F-4 pilot could gain a tactical advantage over an attacking MiG-17 by immediately converting airspeed into altitude. However, this tactic required the Phantom to possess sufficient specific excess power to accelerate in the vertical plane.

If the Phantom had only marginal specific excess power or lacked the altitude to perform a tight, diving turn away from the MiG-17, the communist pilot probably won the engagement. An F-4 usually could not compete with the MiG-17's vastly superior turn rate unless the Phantom pilot properly maximized the aircraft's ability to operate in the vertical plane. Furthermore, this tactic assumed that the enemy aircraft was not armed with heat-seeking Atoll missiles, which the MiG-17 generally did not carry.

Fortunately for the United States, the North Vietnamese Air Force never posed a serious threat. In all fairness, the F-105 and F-4 were not the only aircraft in Vietnam plagued with design problems. The Phantom was a magnificent aircraft and should be regarded as one of the best fighters ever built. Phantom production spanned more than two decades (1955–79), and McDonnell made over five thousand Phantoms in twelve different variants. The air forces of eleven different nations flew the F-4, and it was the only fighter ever to be used by the U.S. Air Force, Navy, and Marine Corps. Fighter aircraft design requires many difficult decisions, and no design is perfect. The two fighter types discussed at length in this chapter are, however, typical examples of how the preoccupation with a Soviet nuclear conflict left the United States unprepared for the war in Southeast Asia.

Four magnificent Republic F-105D Thunderchiefs in a diamond formation. USAF photo, courtesy Jim Van Namee.

Fastest gunfighters in the world. First Lt. Jack Smallwood *(left)* and Maj. Phil Handley *(right)* pose with the crew chief of F-4E, serial number 68–210, shortly after making what is believed to be the fastest gun kill ever made. The crew of Brenda 01 downed a North Vietnamese MiG-19 on June 2, 1972, with the Phantom's internal 20-mm Gatling gun. Theirs was also the first kill made with the F-4E's internal cannon and the only MiG-19 to be downed by cannon fire during the Vietnam War. USAF photo by A1C Gerald R. Brownson, courtesy Phil Handley.

A beautifully restored F-86E Sabre in 51st Fighter Interceptor Wing markings. Author's collection.

An ace and his Sabre. Capt. Robinson Risner poses by the cockpit of his F-86E. Risner shot down eight enemy aircraft during the Korean War. He earned his first Air Force Cross for placing the nose of his Sabre into the exhaust pipe of his wingman, who had run out of fuel over North Korea. Risner pushed his wingman's damaged plane for more than a hundred miles across enemy territory to the China Sea. The wingman then ejected but unfortunately drowned during the rescue attempt. Risner commanded the 67th Tactical Fighter Squadron, which flew F-105 Thunderchiefs, in Vietnam. He was shot down by AAA on March 22, 1965, and rescued. North Vietnamese gunners again shot Risner down on September 16, 1965. This time, however, he was captured and spent the next seven and a half years as a prisoner of war. Risner received his second Air Force Cross for his exemplary leadership and bravery as a POW. USAF photo, courtesy Robinson Risner.

A nicely restored MiG-15 Fagot. Notice the external similarities to the F-86 Sabre. Superior pilot training usually determines the outcome of any engagement. Courtesy Candid-Aero Files.

The small but deadly MiG-17 Fresco. Although considered obsolete by 1965, it was "a vicious . . . vicious little beast" to both air force and navy pilots in Vietnam. Courtesy Candid-Aero Files.

Two Air National Guard F-100D Super Sabres in formation above the clouds. The "Hun" was the world's first production aircraft to achieve sustained supersonic flight, but it was not nearly as maneuverable as its predecessor, the F-86 Sabre. The D-model aircraft, as shown here, was developed for the ground-attack mission only. In the Vietnam War, F-100Ds flew 344,619 combat and combat-support sorties, mostly in South Vietnam. Courtesy JEM Aviation Slides.

Lockheed's "missile with a man in it" shown in Vietnam-era camouflage and flown by the Puerto Rican Air National Guard. The F-104 Starfighter was an ideal interceptor, but saw only limited duty in Southeast Asia. Notice the extremely short, stubby wings. Courtesy Candid-Aero Files.

Convair's F-102 Delta Dagger was another interceptor that saw only minimal service in Vietnam. On February 3, 1968, two North Vietnamese MiG-21s engaged two F-102s from the 509th Fighter Interceptor Squadron. One of the F-102s was destroyed by an Atoll infrared-guided missile. The pilot, Lt. W. L. Wiggins, was declared missing in action. Courtesy Candid-Aero Files.

Five F-105 Thunderchiefs in flight. Republic's legendary fighter-bomber flew nearly 158,000 combat and combat-support sorties over Southeast Asia. More than half of those missions were to targets in North Vietnam. The Thunderchief could survive severe damage, yet 58 percent of all available combat-ready F-105s were lost during the war. USAF photo, courtesy Jim Van Namee.

Lt. Jim Ray and his F-105D. Shortly after this photograph was taken, Lieutenant Ray was shot down by North Vietnamese AAA. He was captured and spent the next six years as a POW. USAF photo, courtesy Jim Ray.

F-105D pilot Col. Kennith F. Hite celebrates the completion of his one hundredth mission over North Vietnam. Colonel Hite was the commanding officer of the 44th Tactical Fighter Squadron. Courtesy Kennith F. Hite.

The first of more than five thousand. McDonnell's first production F-4 Phantom II undergoing taxi tests. Note that the main landing gear doors have been removed. Courtesy The Boeing Company.

The most advanced fighter in the North Vietnamese Air Force was the Soviet MiG-21 Fishbed, shown here in service with the Hungarian Air Force. North Vietnamese pilots generally preferred the older, slower, cannon-equipped MiG-17 Fresco. Courtesy Candid-Aero Files.

An F-4C Phantom II with an SUU-16 gun pod suspended from the centerline hard point. The SUU-16 is a 20-mm Gatling gun capable of firing up to six thousand rounds of ammunition a minute. Courtesy JEM Aviation Slides.

An Iron Hand strike force refuels before entering North Vietnam. The two F-105Fs in the foreground carry AGM-45 Shrike missiles that seek enemy radar frequencies and then follow the signal to its source. The F-105D in the background carries a load of conventional bombs to finish destroying the SA-2 site. These hunter-killer teams were quite effective in protecting the main strike force from the SAMs. Courtesy Alton Meyer, via Jim Ray.

An F-105F Thunderchief "Wild Weasel" on its way to North Vietnam. This Weasel, flown by Maj. J. F. Dudash with Capt. A. B. Meyer as the electronic warfare officer, is armed with AGM-45 Shrike antiradiation missiles and conventional bombs. On April 26, 1967, an SA-2 missile hit their aircraft. Major Dudash perished in the crash, and Captain Meyer became a prisoner of war for the next six years. Courtesy Alton Meyer, via Jim Ray.

F-4G Wild Weasel. Courtesy JEM Aviation Slides.

"Last of the Gunfighters"—two Vought F8 Crusaders from navy fighter squadron VF-201 in formation. Both aircraft have recently fired their AIM-9 Sidewinder missiles. Courtesy JEM Aviation Slides.

An air force T-38 Aggressor in Soviet-style markings. Courtesy Candid-Aero Files.

It may have been short, it may have been little, and to some misguided souls it may have been ugly, but Vought's successful A-7D Corsair II certainly accomplished its mission. When the air force accepted the A-7D, it marked the end of the interceptor mentality and the rebirth of the air-superiority aircraft. Courtesy JEM Aviation Slides.

Changing of the guard. F-4 Phantoms share the production line with the new F-15A Eagle at McDonnell's St. Louis, Missouri, factory. Courtesy The Boeing Company.

Cockpit of the F-15A Eagle. Notice the head-up display, rearview mirrors, well laid-out instrument panel, and excellent visibility. Courtesy The Boeing Company.

Perhaps the greatest benefit of a "fly-by-wire" control system is survivability. This Israeli F-15 Eagle suffered a midair collision that sheared the entire right wing from the airplane outboard of the wing root. The pilot flew back to his base on one wing and made a safe landing. The airplane only needed new tires, brakes—and a right wing before returning to duty. Courtesy The Boeing Company.

An F-15A launches an improved AIM-7F Sparrow missile. The Sparrow is a radar-guided missile. Courtesy The Boeing Company.

CHAPTER 4

"We're a Little Lacking There"

After Capt. Leroy W. Thornal successfully completed his air force combat tour in Vietnam and returned to the United States in the summer of 1967, Maj. Henry Shallcross interviewed him for the Corona Harvest program. In the debriefing, Major Shallcross asked, "How about your people, were they well qualified for the most part to do the job there [in Vietnam]?" Captain Thornal thoughtfully replied:

> Well, they talk about people being qualified. I think you have to qualify this statement itself on the question. That is if you're talking about qualified and being able to fly the airplane, yes. Because the training that we underwent at George [Air Force Base] to check out the airplane I think this was well enough to qualify a man to go over and drop bombs, and shot [*sic*] up trucks and fuel oil storage areas and things of this nature. . . . But to put a man up in the environment, up around Hanoi, maybe I think we're a little lacking there, because this is something you can only gain by experience by going up there so many times and knows whats [*sic*] around and how to cope with the defenses that they have up there. For instance, the SAMs. The SAM is an awesome thing if you've ever seen one. But until you've seen one of them where you're scared to death of the thing before you even get up there because you've heard so many stories about them. But

> once you see it, then you really get scared until you find out what you can do to engage that attack. Once you find out howto [*sic*] engage it, then you build up your confidence against the SAM. Although you're still worried about it—ts [*sic*] there. But being qualified to fly around the Hanoi area, if we're talking about SAMs, then the only way you can gain experience . . . is to get up there and fly in that area—if you survive that long.[1]

"If you survive that long" was a sincere sentiment and not a statement filled with hyperbole or macabre sarcasm. The surface-to-air missile threat, however, represents one of the great avoidable tragedies of the Vietnam War. Both the air force and the navy forgot their respective experiences in World War II and Korea and generally ignored a valuable lesson from the Cuban missile crisis.

In 1953 the United States learned that the Soviet Union had successfully developed a surface-launched missile capable of intercepting and destroying an airplane in flight. The missile, known as the SA-1, evolved from the German Wasserfall of World War II. Like their former British and American allies, the Soviet Union had captured its share of Nazi technical documents and scientists, including several men who had been involved in the Wasserfall project. The Soviets used the captured German technology to produce the SA-1.[2] Four years later, the Russians revealed an improved version of the SA-1, the SA-2 (NATO code name Guideline), in the 1957 May Day parade.

The thirty-five-foot-long SA-2 missile consisted of a first-stage solid-fueled booster rocket, a second-stage liquid-fueled rocket, and a 288-pound explosive warhead that could be command detonated, impact detonated, or detonated by a proximity fuse. The warhead was a shaped charge that exploded in a conical pattern. If an airplane passed through the cone anywhere between its origin and the point where the cone had reached a radius of two hundred feet, it generally was destroyed. The Mach 3.5 missile required constant guidance control from two ground-based radars. The Spoon Rest (NATO designation) radar system performed the initial acquisition of the airborne target and the Fan Song radar controlled the SA-2 missile acquisition and tracking functions.[3] Because the booster rocket casing covered the SA-2's guidance antenna, the missile was unguided until the first stage separated—usually at an altitude of 2,000 feet. The Guideline's effective altitude thus extended from approximately 2,000 feet to about 60,000 feet, and the SA-2 operational range reached to roughly nineteen miles.

On May 1, 1960, a U-2 reconnaissance aircraft piloted by Francis Gary Powers was downed over the Soviet Union by an SA-2. No aircraft in the Soviet arsenal could reach the operational altitude of the American U-2, but the Soviets defiantly scrambled an Su-9 and two MiG-19P Farmer Bs in hopes of intercepting the spy plane assigned to photograph the military-industrial complexes at Sverdlovsk. The unarmed Su-9 was ordered to ram the U-2, but its pilot, Capt. I. Mientyukov, never spotted the spy plane. Fourteen SA-2 missiles were also fired at the American aircraft, and the shock wave from one of the missiles succeeded in shearing the vertical stabilizer from the fragile U-2. An SA-2 also acquired and destroyed one of the MiG-19P interceptors. The pilot perished when he ejected.[4]

During the Cuban missile crisis, an SA-2 destroyed an air force U-2 flown by Maj. Rudolph Anderson on October 27, 1962. Major Anderson perished in the attack.[5] The United States thus lost two airplanes to SAMs two years before the Gulf of Tonkin incident, and American intelligence experts had known of the threat posed by surface-to-air missiles seven years before Francis Gary Powers left the runway for that infamous flight over Sverdlovsk.

On April 5, 1965, an RF8A Crusader from the USS *Coral Sea* photographed an SA-2 construction site fifteen miles southeast of Hanoi.[6] On May 25, the Soviet Union announced to the world that Hanoi would be protected by a curtain of SAM missiles, and the first loss to a SAM in Vietnam occurred on July 24 when three SA-2 missiles were launched after a flight of three air force F-4C Phantoms approximately fifty-five miles northwest of Hanoi. One of the three Guidelines detonated within the formation, destroying one of the Phantoms and damaging the other two aircraft.[7]

The first reprisal strike against a SAM site was flown three days later.[8] The air force and navy rapidly developed a SAM search-and-destroy strategy known as Iron Hand. The plan seemed simple enough: Two aircraft flew in a hunter-killer team, each looking for the missile site. Once the SAM site was visually located, the first aircraft would drop napalm on it, and the second would follow up with large conventional bombs. Iron Hand missions began on August 12, but it was not until October 17 that a SAM site was successfully destroyed. Four navy A4Es and an A6 from the USS *Independence* destroyed a site near the Kep airfield in North Vietnam.[9] As with most hastily conceived plans involving sophisticated technology, Iron Hand missions proved to be of limited value. Air force and navy crews had destroyed eight SAM sites by the end of November, 1965, but at a cost of three air force F-105 Thunderchiefs, two navy F8 Crusaders, two air force F-4 Phantoms, and a navy A4 Skyhawk.[10] Eight aircraft and ten highly trained airmen exchanged for eight SAM sites made the cost of Iron Hand missions prohibitive.

In response to the missile threat, the air force and navy changed tactics. In World War II and Korea, tactical bombing attacks were flown at altitudes of between 5,000 and 10,000 feet—well above the range of small-arms fire, radar-controlled automatic weapons (AW) fire, and small-caliber AAA (usually 23- and 37-mm cannon). Above 4,000 feet, the lethality of small-caliber AAA and AW is greatly reduced; below 4,000 feet, such weapons can be most deadly. Although the North Vietnamese possessed large-caliber 57-, 85-, 100-, and 120-mm antiaircraft guns that could reach altitudes of 20,000 feet, it was virtually ineffective against a flight of fast-moving jet aircraft. Large artillery pieces have slow rates of fire, and their effectiveness is further complicated by the physical difficulties of calculating exactly when to fire a round so that it will intersect with an aircraft flying at 550 knots at an altitude of 15,000 feet. But flying at altitudes above the reach of small arms and automatic weapons fire greatly increased an aircraft's vulnerability to surface-to-air missiles. Since American intelligence agencies knew that the SA-2 was basically an unguided missile from the ground to about 2,000 feet, the strike planners ordered pilots to initiate attacks at much lower altitudes, typically around a mere 1,000 feet above the ground.

Naval aviator Richard Wyman flew F8 Crusaders from the USS *Oriskany* in 1966. Reflecting upon the tactic of flying strike missions at very low altitudes, Wyman stated:

"The theory was, in those days, that if they shot [SAM] missiles, you got as low as possible in order to defeat them. That was the theory. You tried to grab the dirt. Somebody called 'SAMS!' and we all dove for the deck. There were twenty-four airplanes trying to fit into a small valley at five hundred knots apiece, fifty feet off the ground. Talk about wild—that was all the wildness a person could stand. You had the possibility of a midair collision, of hitting the ground, or of getting shot down [by small arms or AW fire]."[11]

The American intelligence community also believed that Soviet AAA and AW fire control radars could not acquire and track several targets traveling at speeds in excess of four hundred knots quickly enough to accurately achieve a firing solution. Although this was true to some degree, the Vietnamese gunners responded by turning the radars off and creating a barrage of fire over the target. As fellow F8 pilot Cmdr. John Nichols noted: "The secret was no secret at all. Gunners didn't have to track a jet. All they had to do was draw a straight line between the airplane's roll in point and its target, then fill that portion of sky with as much steel as possible. Regardless of its speed, the jet had to fly through that box. At that point probability theory takes over. It becomes a crapshoot. . . . Pure concentration [of AAA and AW guns] was the name of the game—concentration and fire discipline."[12]

The technical description for the above tactic is known as "area of real-time tracking." To better understand this concept and how altitude improves one's odds of surviving AAA and AW fire, pretend that you are standing in the end zone of a football field with a very powerful water hose in your hand. Your neighbor's dog, which entertains you late at night with its incessant barking, is conveniently sitting on the thirty-yard line. Seeing an opportunity to exact a little revenge, you promptly aim the nozzle toward the dog, which then runs away. Most dogs cannot run faster than you can move the hose's nozzle, but the relative motion of the dog with respect to you is such that it is difficult for you to calculate a tracking course that will splash it. The dog is outside your area of real-time tracking. If the dog is sitting on the ten-yard line, however, it will be unable to avoid your watery wrath. The dog is running just as fast as before, but the short distance between you and the dog places it inside your area of real-time tracking. The same analogy applies to airplanes: as altitude decreases, the area of real-time tracking for AAA and AW increases.

American aircraft continued to attack their targets from low altitudes to reduce the SAM threat as much as possible. Commander Nichols remarked: "the conventional wisdom maintained that space-age missiles were the primary threat. It had to be the case; everybody said so."[13] Reflecting upon the loss of the navy's Lt. Everett J. Alvarez during the reprisal strikes flown in the aftermath of the Gulf of Tonkin incident, Commander Nichols said:

> Losing Alvarez was very sobering. We came back quiet; a lot of people were just thinking, just amazed a jet was getting shot down in combat. People were saying, "How the [expletive]

> could that happen? How can a pilot in this day and age get shot down by guns?" Of course, there were pilots on the ship who had been flying the F9F-2 in Korea, and they said, "We're learning the lesson all over again. The North Koreans shot us down with no problem [when we were] flying the F9F-2, and we learned [that] you don't go below thirty-five hundred feet. And here you kids are practicing low and slow maneuvers." Ask any pilot training at Lemoore Naval Air Station in the early 1960s. We were practicing low and slow, half flaps, two hundred and some miles per hour. [Expletive], they were going to shoot us out of the sky with a slingshot. Somehow in our crazy minds we lost the lessons of Korea, and they knocked Alvarez down. By 1968, no one, and I mean no one, was going below thirty-five hundred feet. To do that was the kiss of death and those were hard lessons to learn. We lost a lot of pilots, and a lot spent many hours in the Hanoi Hilton [Hoa Lo Prison] because they went below thirty-five hundred [feet].[14]

Defeating a radar-guided surface-to-air missile is truly a "deadly game of tag." Once a pilot or other crew member either sees the telltale cloud of dust billowing up from a SAM site or receives an indication from his radar homing and warning receiver that a missile has been launched, he immediately turns into the missile, placing it at near his ten o'clock or two o'clock position. Visually locating and following the missile's path is the key to defeating it. Once the pilot sees the missile, he pushes the nose of the aircraft down and dives toward the ground. Since a SAM is programmed to fly on a lead-collision course, this diving maneuver lets the pilot know what to do next. If the missile does not alter its course to lead pursuit, it is not tracking the airplane and the pilot can level off and continue the mission while remaining alert for other SAM launches.

If the missile's nose begins to point in lead pursuit along the aircraft's projected flight path, it is being guided to impact with the airplane. This is when the pilot's timing "has to be absolutely exquisite." The pilot continues the dive in an attempt to commit the missile to a nose-low altitude until the missile resembles the approximate size of a Number 2 lead pencil being held at arm's length above your head. At that moment, the pilot executes a sharp, high-g pull-up. The missile's Mach 3.5 airspeed and small control surfaces cannot match the aircraft's turn radius, and the missile's warhead will detonate harmlessly below the aircraft's flight path.

The low strike altitudes may have lessened the SAM threat, but they increased the effectiveness of small arms and automatic weapons fire. Table 5 lists the fixed-wing aircraft in-flight combat losses by weapon system and by branch of service.

For a better understanding of the damage inflicted by small arms, AW, AAA, and SAMs, table 6 translates the numerical data from table 5 into percentages.

As table 6 illustrates, nearly 80 percent of all American fixed-wing aircraft losses in the air war over Southeast Asia were attributed to radar-controlled AAA and AW. Pilots begged for a device that

Table 5.
Fixed-Wing Aircraft In-flight Combat Losses by Weapon System and by Branch of Service for All of Southeast Asia, January, 1962–January, 1973

	SA/AW	AAA	SAM	MiGs	Own Ordnance	Unknown or Other	Total A/C Lost
Air Force	751	410	106	66	7	266	1,606
Navy	96	197	81	12	16	136	538
Marine Corps	83	25	4	1	2	58	173
Total	930	632	191	79	25	460	2,316

Source: CNA Database.

Table 6.
Percentage of Fixed-Wing Aircraft In-flight Combat Losses by Weapon System and by Branch of Service for All of Southeast Asia, January, 1962–January, 1973

	SA/AW	AAA	SAM
Air Force	47%	26%	7%
Navy	18%	37%	15%
Marine Corps	50%	14%	2%
Total	45%	31%	9%

Source: CNA Database.

would dispense chaff (bundles of small aluminum-foil strips) from an airplane. The metal strips reflect radar waves in a way that either masks the aircraft from detection, or tricks the radar receiver into seeing multiple targets when only one exists. Chaff, which was used extensively in World War II, could have been used to render North Vietnamese fire-control radars virtually ineffective, but the air force did not purchase a chaff-and-flare dispenser unit (the ALE-40) until the late 1970s.[15]

The SAM threat and the resulting losses to conventional antiaircraft weapons in 1965 and 1966 can only be classified as the result of an inexcusable act of negligence. North Vietnamese surface-to-air missiles found the U.S. military without an adequate defensive strategy. This tragedy is further amplified by the fact that the U.S. military had a decade in which to prepare a missile defense system, but squandered that precious opportunity. Moreover, the air force failed to remember the vital contributions made by its anti-radar squadrons in World War II and Korea.

During the Battle of Britain, the German Luftwaffe learned the value of an early warning radar network. The British Chain Home radar system detected inbound Nazi aircraft, which allowed Royal Air Force pilots sufficient time to intercept the enemy aircraft. The Germans soon developed their own early warning radar network of Wasserman, Freya, and Wurzburg radars. Like their British counterparts, Luftwaffe pilots soon enjoyed the advantage of early-warning radar, which enabled them to intercept Allied bomber formations as they approached Europe.

The word *radar* is an acronym for radio detecting and ranging. A radar station basically consists of a radio transmitter that sends electromagnetic waves into the sky, and a receiving unit. Whenever the transmitted electromagnetic waves strike a dense object, such as a metal wing or fuselage, they are reflected back to the receiver and a potential target is detected. To determine the range to the target, the receiver measures the elapsed time between the transmission and its return. Since radio waves travel at a known velocity, the distance from the target to the radar site can be computed by multiplying the wave velocity and the elapsed time.

Allied scientists learned that any radar unit can be rendered useless by transmitting a radio signal on the operating frequency of that radar—a process known as jamming. The lead aircraft in Allied bomber formations soon began carrying either "Carpet" or "Mandrel" radio transmitters mounted in the bomb bay. Carpet radio transmitters operated against the Freya system, and the Mandrel system broadcast on the Wurzburg frequency. Active destruction of German radar sites began on April 21, 1943, when B-17F Flying Fortress bombers of the USAAF's 16th Reconnaissance Squadron (RS) completed their first mission. The 16th RS quickly became known as the 16th Ferret Squadron, but unlike a real ferret, the B-17Fs possessed no ability to kill their prey. Instead, the 16th RS's aircraft attempted to precisely locate the German radar sites and then vector a strike force in to the target.[16]

As the war progressed, Allied scientists also discovered that radar could be rendered temporarily worthless by releasing chaff. Allied bomber formations, numbering in the hundreds of aircraft, soon carried bundles of chaff to thoroughly confuse the German early-warning radar networks.

Antiradar tactics varied slightly in the Pacific theater. Japanese radar development lagged behind that of the Germans, British, and Americans until November, 1943, when the Nazis supplied the Japanese with plans for the Freya and Wurzburg systems.[17] Instead of one lone squadron of ferrets, four squadrons of either B-24 Liberator or B-29 Superfortress aircraft were outfitted for the radar-jamming mission in the Pacific. Incidentally, the USAAF in the Pacific referred to the ferrets as "Ravens," a name that would be recycled in 1977 for the sophisticated EF-111A jamming aircraft.

The USAAF tasked B-25 Mitchell bombers with the destruction of Japanese early-warning radar sites. Equipped with radar signal homing devices, the B-25s received the enemy radar signal and then followed it to its source. Once the pilot spotted the radar site, he would strafe it with the eight .50-caliber machine guns mounted in the aircraft's nose.[18] The radar-jamming and radar-destruction programs proved very successful in both Europe and the Pacific, but the USAAF abandoned those missions after the war. With the entire world at peace, any further expenditure for developments in radar-suppression technology seemed wasteful.

The Korean War caught the United States completely unprepared to wage electronic warfare. The Soviets spent the years following World War II continually improving their radar-guided AAA, AW, and searchlights. American scientists and engineers made significant advancements in radar technology during the postwar years, but the newly established U.S. Air Force had virtually ignored the field of radar countermeasures. North Korean forces, equipped with sophisticated Soviet antiaircraft weapons, devastated the large formations of American B-29 Superfortress bombers.

In response to the losses, the air force installed radar-jamming equipment in the lead aircraft of a bomber formation and equipped the bombers with chaff dispensers. In 1951, the air force began mounting APA-24 radar-homing receivers in the nose of B-26 Invader aircraft. Using the same tactics that their predecessors had employed against the Japanese, the modified Invaders flew missions to destroy North Korean radar sites. The APA-24 receiver would first acquire an enemy radar signal and then direct the pilot toward the hostile transmitter. After locating the radar, the Invaders would strafe, bomb, or rocket the site.[19]

After the guns grew silent in Korea, the air force temporarily kept the radar countermeasure mission alive through the 9th TRS at Shaw AFB, South Carolina. The 9th TRS continued flying the venerable B-26s equipped with the APA-24 receivers. In 1955, the 9th TRS participated in Exercise Sage Brush, flying both the active and passive radar countermeasure roles. The final report on Exercise Sage Brush praised the 9th TRS's performance and heartily encouraged the air force to continually improve the equipment and training of the radar suppression crews. Unfortunately, the air force's leaders disagreed, and the 9th TRS soon exchanged their Invaders for the Douglas RB-66 Destroyer photoreconnaissance aircraft.[20] The air force thus abandoned the radar countermeasure mission about the same time that the first production SA-2 missiles were being paraded through Red Square.

Given the air force's successful history of defeating early-warning radar in World War II, and given the experience of Korea where early-warning radar, radar-guided searchlights, and radar-guided AW and AAA caused exorbitantly high aircraft losses, one must question why the air force eliminated its one radar-suppression squadron. Furthermore, after the May 1, 1960, incident involving Francis Gary Powers, or even after the loss of an air force U-2 aircraft and pilot to an SA-2 during the Cuban missile crisis, why did the air force not reequip and retrain the 9th TRS (or some other unit) for the antiradar mission? Why did the air force commit such a flagrant act of institutional negligence by not preparing its crews to cope with the SAM menace?

No official explanation or rationalization for those disturbing questions has ever been provided. One can only speculate, but perhaps the perceived threat actually limited technology in this case. American defense analysts ignored the effectiveness of radar-guided AAA and AW in Korea by assuming that any future war would involve a supersonic, low-level dash into the Soviet Union. The extreme low-altitude flight into Russia, they theorized, would negate the SAM threat. Unfortunately, AAA and AW fire were just as lethal in the Vietnam War as they had been fifteen years earlier in Korea.

Furthermore, the air-war planners knew that the Soviets could not surround their border with a curtain of surface-to-air-missiles. Such a project would be cost prohibitive for any nation. Strategic Air Command's heavy bombers and TAC's interdiction bombers could circumvent these missile sites, thus making SAM countermeasures unnecessary. Assuming that American bombers could probably exploit gaps in Soviet air defenses, the same American strategists ignored one very important issue: What happens when the target area is protected by a ring of SA-2 missiles, radar-guided AAA, and MiG bases? The communists wisely protected potential target areas with sophisticated air-defense systems and placed little emphasis on constructing a SAM barrier around the perimeter of the Soviet Union.

Perhaps another reason for the air force's disregard for radar countermeasures can be found from the converse of a statement made by historian Earl Tilford. Discussing the lowly status of the Air Defense Command in the 1960s, Tilford wrote: "The Air Force leadership assumed that since the bomber would always get through, the possibility of an effective air defense was remote; hence, air defense was somewhat heretical."[21] Thus, the air defense of the continental United States during that decade consisted primarily of an extensive early-warning radar network and strategically located interceptor squadrons.

If the air force's leaders believed that Soviet bombers would penetrate U.S. air space, they also "knew" that American bombers would reach their targets in the Soviet Union. Although MiG fighters and SA-2 missiles might intercept and destroy a large portion of the American bomber fleet, air force planners knew that the surviving aircraft would still bring unprecedented destruction to Soviet cities. Furthermore, since this mission would involve a single, devastating nuclear attack on the Soviet Union, it would be useless to develop SA-2 countermeasures. The air force considered it wasteful to allocate money toward a defensive system of uncertain effectiveness that would be used only once. Instead, that money could be used to purchase more B-52 bombers, and thus increase America's offensive capability.

As the number of aircraft lost to surface-to-air missiles steadily increased, the air force formed an investigative committee under the leadership of Gen. Kenneth C. Dempster on August 13, 1965. The Air Staff Task Force on SAM Missiles was asked to answer one question: "What is the most effective means of neutralizing the threat posed by SAM missiles and heavy anti-aircraft in the Southeast Asia conflict?"[22] The committee's response was that "Several attempts at neutralizing selected SAM sites in the Hanoi area resulted in heavy losses to attacking U.S. aircraft from intense and accurate medium and heavy automatic weapons fire."[23] Furthermore, "Attacks against SAM sites with present tactics, currently available weapons, and the SAM mobility, have resulted in less than desired results. The PACAF Commander has voiced an urgent requirement for solution to this problem."[24]

The committee learned that the Bendix Corporation had recently proposed installing QRC-253–2 radar homing and warning receivers in F-100 Super Sabres, and that the air force had rejected that offer. Therefore, the equipment needed to detect Fan Song radar emissions was readily available. The Dempster Committee accepted bids for the installation of the RHAW gear from both Bendix and Applied Technologies on August 3, 1965.[25] Those present at that momentous meeting between the air force and industry said no formal agreement was signed. Instead, "A contract was sketched out on a blackboard and photographed for the record. On the basis of this record and a handshake, work began. It was that kind of problem."[26]

The report authorized Applied Technologies to install a Vector IV RHAW system in a two-seat F-100F Super Sabre at North American Aviation's plant in Long Beach, California. The Vector IV receiver (later known as the APR-25 RHAW) could scan the S-, C-, and X-band frequencies; indicate which type of radar frequency was in use; and then direct the pilot to the radar site. Next, an IR-133 panoramic receiver unit was installed. The IR-133 determined the type of radar system being used against the aircraft: ground control intercept (GCI), radar-guided antiaircraft artillery, or surface-to-air missile guidance radar. Finally, a WR-300 launch warning receiver (LWR) was installed. The WR-300, later renamed the APR-26 LWR, detected SA-2 launches by monitoring the missile guidance frequency. If the signal strength suddenly increased, a launch had probably occurred.[27]

The air force asked five of its best F-100 pilots and five of the most-competent B-52 Stratofortress radar navigators to volunteer for Project Wild Weasel. Another pilot and navigator soon joined the project, and the six teams flew to Eglin AFB, Florida, for a month of training. Since the navigators no longer were responsible for charting the airplane's course, they officially became known as electronic warfare officers (EWOs). The Wild Weasel pilots, however, referred to them as either "GIBs" (Guy in Back) or "Bears." Major Milton Rickman first called the EWOs "Bears" at a 1966 party in the officer's club at Takhli Air Base in Thailand. The major asked the assembled crowd:

> Do you remember the shooting gallery section in the arcades of the amusement parks? If so, you undoubtedly remember the electronic rifle apparatus that had a large bear running back and forth at the end. Every time you hit him, the bear would stop running, rear up on his hind legs, and roar before turning about and continuing on. Well, that's what these EWOs flying against the SAMs up North [over North Vietnam] remind me of. Every time the SAMs fire at them, you'll see the EWO put his paws up on the back seat canopy rail and roar defiantly at the missiles as they whiz by his aircraft. So instead of GIBs, as we've always called them, I propose to rename our Wild Weasel EWOs "Bears."[28]

The six crews trained by flying against a simulated Fan Song radar transmitter at Eglin known as the Soviet Air Defense Simulator. The Wild Weasel strategy called for the F-100Fs to escort a strike force until the RHAW gear announced that a Fan Song radar was operational and could provide a direction to the transmitter. Then the Wild Weasels flew toward the radar site, visually acquired it, and destroyed it with conventional gravity bombs. After extending the Wild Weasel training course for another month, the six crews departed for Southeast Asia on November 21, 1965—eighty-four days after the Dempster Committee first convened.[29]

Captain Edward White and Maj. Edward Sandelius flew the first Wild Weasel mission on December 1, 1965, but they failed to destroy any SA-2 sites.[30] The specially trained crews continued flying two SAM suppression missions a day without seeing any results. Tragedy struck the Wild Weasel program on December 20, 1965, when Capts. John Pitchford and Robert Trier were shot down. The local militia captured Captain Pitchford and killed Captain Trier. After his release in 1973, Captain Pitchford stated that he never saw what destroyed his aircraft.[31]

Better times awaited the Wild Weasel crews, however. Captains Al Lamb and John Donovan avenged the loss of Captains Pitchford and Trier by destroying a SAM site on December 22, 1965—the first kill by a Wild Weasel team. Both men received the Distinguished Flying Cross for that mission. Captain Lamb later destroyed two more missile sites, and Captain Donovan returned to the United States to teach at the EWO school at Nellis AFB, Nevada.[32]

The seven original F-100F Weasels destroyed a total of nine SA-2 sites, but success did not come easily. Two of the highly modified Super Sabres were shot down, one was lost in a landing accident, and one crew overstressed an airframe to the point that it was permanently bowed. The remaining four aircraft were eventually damaged beyond repair.[33] Three substantial problems surfaced with the first-generation Wild Weasel equipment. The APR-25 RHAW system was incapable of providing a range estimate to the Fan Song radar unit. The Weasel crews thus had to fly the indicated heading until they visually located the often-camouflaged missile sites. By then, the Weasels were exposed to not only the SA-2 missiles, but also to heavily concentrated AAA used in defending the site.

After visually acquiring the missile launch area, the Weasels dropped conventional ordnance onto the site. Despite the Weasel crews' best efforts, the iron bombs frequently missed their intended targets. For a brief period, the Wild Weasels attempted to destroy radar sites with canisters of napalm, but the burning jellied gasoline produced a thick blanket of smoke that completely obscured the target area.[34] Moreover, delivering napalm effectively requires the pilot to fly a steady and level approach at an altitude of about fifty feet above the ground—a very attractive target to an angry AW gunner. A more accurate and destructive antiradar ordnance was needed before Weasel lethality could be improved.

The F-100F was initially chosen for the Wild Weasel mission because "it was fairly fast, it was available, and it had room to accommodate the prototype black boxes that the engineers were trying to cobble together. And it was cheap, even then, with a unit cost of only about $600,000."[35] As previously noted, the F-100 was originally designed to be a supersonic, high-altitude fighter-interceptor but evolved into a ground-attack aircraft. It therefore suffered from both poor maneuverability and poor performance at low altitudes.

Furthermore, it was slower than the F-105 Thunderchiefs that it was supposed to escort, but this fact led to one of the more colorful Wild Weasel slogans: "First in and last out." Although this motto implied that the Weasel crews possessed extraordinary bravery, it actually described how the slower F-100s had to take off long before the much faster F-105 Thunderchief strike force so that they could rendezvous over the target area. After the Thuds bombed their target, the Weasels were then left to "struggle out behind . . . [the strike force] as best they could."[36] The F-model Super Sabre validated the Wild Weasel concept, but it was ill suited for the mission. For the active radar-suppression program to successfully continue, a faster (if not more agile), sturdier, Weasel aircraft with improved electronics and ordnance was needed.

The improved ordnance arrived in March, 1966, courtesy of the U.S. Navy. In 1958, the navy asked Texas Instruments (TI) to develop a missile capable of homing on an enemy radar transmission. The Cuban missile crisis had confirmed the value of just such a missile, and the navy asked TI to continue developing the AGM-45 Shrike with all deliberate speed. The Shrike missile was ten feet long, weighed 390 pounds, and flew at a speed of Mach 1.5. Its range varied with launch conditions but was generally around twelve miles.

The AGM-45 could home in on only one of the thirteen known Soviet radar frequencies, but TI created seeker units for each frequency. Ordnance men installed the appropriate seeker unit for the intended type of radar before loading the missile onto the aircraft. The Shrike's 145-pound warhead destroyed the enemy radar transmitter with twenty-three thousand steel fragments. The air force quickly procured AGM-45 missiles from the navy, and the Wild Weasels flew their first Shrike-armed missions on April 18, 1966.[37] The Shrike greatly increased the probability that the SA-2 site would be destroyed while also significantly decreasing a Weasel's exposure to SA-2s and AAA.

The air force decided to simultaneously develop both the F-4C Phantom and the F-105F for the Weasel mission. The F-4C was formally known as the Wild Weasel II, but crews labeled it the "Weasel in a can." Instead of removing some of the existing Phantom avionics and wiring to make room for the active radar-suppression equipment—a very labor intensive and time consuming effort—the new Weasel II electronics gear was inserted into pods and suspended from the multiple ejector racks below the wing. Although the second-generation Weasel electronics were much improved over the original system, their performance suffered in the pod-mounted position because of vibration and transient voltage problems.[38] Moreover, this location further limited mission effectiveness by reducing the amount of ordnance or fuel tanks that the F-4C could carry. The Phantom airframe proved suitable for the Wild Weasel mission, but the externally mounted electronic equipment needed further refinement. While McDonnell and Advanced Technologies engineers worked together to integrate the new electronics into the Phantom airframe, the air force selected the F-105F to replace the F-100F in the Wild Weasel role.

When General Dempster selected the two-seat version of the Thunderchief to be the next Wild Weasel aircraft on January 8, 1966, he eliminated many of the problems plaguing the program. The F-105F "hunter" could better maintain formation with the F-105D "killer," and the Thud's rugged construction and heavy payload capabilities made it well suited to the Wild Weasel mission. The F-105F Weasel III housed improved versions of the APR-25 RHAW, IR-133C panoramic scan receiver, and the APR-26 LWR, but it also carried an AZ-EL system that provided the Bear with the azimuth and elevation to the Fan Song radar. All F-105F Weasels were modified to launch the Shrike antiradiation missile, and some Weasel III aircraft received the SEE-SAMS(B) passive warning sensor that detected a potential SA-2 launch.[39]

The first Weasel III aircraft arrived in Thailand on May 28, 1966, but the few surviving F-100F Weasels continued flying missions until July 11. Weasel III crews flew their first mission on June 6 and scored their first missile site kill the next day. Later that month, the new Weasels began flying radar destruction missions at night. Unfortunately, no one had thought to add a brightness control to the threat sensor display screens, and the brilliant indicator lights temporarily destroyed the crew's night vision.[40] Eventually, eighty-six F-105Fs were converted to the Wild Weasel III standard, but the air force still desperately needed more Weasel aircraft in Vietnam. Air force intelligence had located more than a hundred active SA-2 sites in North Vietnam by August 1, 1966, yet there were only twenty-five trained crews and eleven Weasel III aircraft in Southeast Asia to counter the threat.[41]

Despite the new and improved equipment, Wild Weasel losses continued to mount. By August 17—less than three months after the F-105F Weasels flew their first mission—five of the original eleven Weasel III aircraft had been shot down.[42] Colonel Edward White, one of the original Wild Weasel pilots, blamed the terribly high loss rate on insufficient crew training and excessive exposure to enemy air defenses (most Weasel missions lasted between two and one-half to three hours).[43] Colonel Harold E. Johnson noted that "It was not unusual for newly arrived Weasel crews to find themselves in the lead aircraft of the lead flight supporting a full 24 aircraft fighter-bomber strike against a prime, heavily defended target close to Hanoi on their very first mission."[44] Consequently, the air force tripled the length of the Wild Weasel training course from four to twelve weeks, and Weasel students flew at least twenty-one practice missions and fired a live AGM-45 missile.[45] Moreover, the air force temporarily halted the hunter-killer missions and tasked the Weasels with escorting the F-105D fighter-bomber strike forces.[46]

Wild Weasel equipment and tactics changed dramatically during 1967. In January, the Seventh Air Force ordered all F-105 Thunderchiefs operating over North Vietnamese airspace to carry at least one AIM-9 Sidewinder missile. Colonel Broughton notes, however, that this order was obeyed only when the missiles were available as the missiles were scarce at this time.[47] The Sidewinder order was intended to help protect the F-105s from MiGs, but it was truly impractical for the Wild Weasels. From the first Weasel mission on December 1, 1965 until January, 1967, Weasel aircraft had encountered MiGs only once: four MiG-17s ambushed a Wild Weasel flight on June 29, 1966, and one F-105F received severe damage to its right stabilator. Regardless, the MiGs failed to shoot down the Weasel.[48] By forcing each Weasel to carry a Sidewinder, Seventh Air Force limited the offensive capability of the SAM killers. Each Sidewinder carried meant one less Shrike or CBU-24/B cluster bomb unit available to destroy an SA-2 site. Seventh Air Force finally exempted the Weasels from the Sidewinder requirement in 1968.[49]

Shortly after the Seventh Air Force exempted the Weasel F-105Fs from carrying a Sidewinder missile, it issued another directive that proved quite challenging to Weasel crews. The externally mounted ALQ-71 electronic countermeasures (ECM) pod had recently become readily available in Southeast Asia, and Seventh Air Force ordered all aircraft operating over North Vietnamese airspace to carry one. The ECM pods, designed to jam the Fan Song radar operating frequencies, proved very effective when properly used. At an altitude of eighteen thousand feet, an ALQ-71 pod provided a "safe" area around the aircraft with a radius of about 6.5 nautical miles—assuming the aircraft was in level flight. Pod performance decreased substantially as bank angle increased. Moreover, before the ECM pods became available, the North Vietnamese would usually only launch a single SA-2 missile at each enemy flight.

After the pods became widely used, the North Vietnamese began launching up to four missiles against each flight, hoping that the multiple launches would destroy the flight integrity and maybe find the strike-force aircraft without sufficient airspeed or altitude to outmaneuver the SAMs. A common North Vietnamese tactic was to launch one missile at the flight, forcing the flight to fixate upon that one missile. While the flight was occupied with defeating that missile, SA-2 batteries on either side of it would launch a missile they hoped would catch the Americans by surprise.

To defeat a multiple-SAM launch, the pilot used a technique similar to the one previously described for defeating a single missile. Once the first missile had been overcome, the pilot could defeat the remaining two or three missiles by executing a series of four-g barrel roll maneuvers. Because of the inherent delay between the tracking radar's analysis of the aircraft's predicted flight path and the command guidance signals received by the missile itself, profound lead collision geometry problems were created.

The ECM pods certainly helped non-Weasel pilots survive their missions to North Vietnam, but the new directive from Seventh Air Force headquarters surely harmed the Weasels' effectiveness. Not only did the ECM pod restrict the Weasels' offensive capability by removing one AGM-45 Shrike missile from each aircraft, it also destroyed the F-105F's ability to ferret out enemy radars. When activated, the ECM equipment jammed both enemy radars and the APR-25 RHAW receiver. Weasel crews clamored incessantly throughout the Seventh Air Force chain of command, but to no avail.[50]

Republic Aircraft, the F-105's manufacturer, improved the situation somewhat by converting sixty F-105F Wild Weasel III aircraft into F-105Gs. The improved Wild Weasel III airplane incorporated the new APR-35/36 RHAW system, the new APR-35 panoramic receiver, and an improved ALR-31 SEE-SAMS passive warning sensor. However the best feature of the refined Wild Weasel III was an internally mounted ECM pod. Westinghouse engineers literally bisected an ALQ-101 ECM pod and mounted each half under a faring along the sides of the fuselage. The F-105 Wild Weasels could once again carry two Shrike missiles on every mission.[51]

The F-105G also was modified to carry the AGM-78B Standard Anti-Radiation Missile (ARM), which General Dynamics had developed for the Navy in 1965. The early Standard ARM consisted of a navy Tartar surface-to-air missile with the seeker unit from an AGM-45–3A Shrike. Thus, the AGM-78A missile was nothing more than a Shrike with a larger warhead and greater range. The improved AGM-78B missile featured a single, all-band seeker unit, a bomb-damage assessment signal, target marking smoke, and, most importantly, a guidance computer with an internal memory circuit.

North Vietnamese Fan Song radar operators learned that they could usually avoid destruction from an AGM-45 Shrike by quickly turning the radar unit on and off, because the Shrike required a constant signal for guidance. If the enemy radar signal was interrupted, the antiradiation missile would usually follow a ballistic trajectory. That tactic did not work against the new AGM-78B, which "remembered" the location of radar transmitter and continued toward the intended target regardless of the Fan Song's operational status. The navy began using Standard ARMs on March 6, 1968, and the first air force mission with the AGM-78 occurred on May 10. On that first mission, the Weasels fired eight Standard ARMs, and five of the antiradiation missiles flew into their targets. One radar site was completely destroyed, one site listed as probably destroyed, and a third site was registered as possibly destroyed.[52]

Since Republic Aircraft had closed the F-105 production lines in 1964, the air force knew that the supply of F-105F and F-105G Wild Weasel III aircraft was limited. Combat losses, operational accidents, and the strain of flying two missions a day quickly reduced the number of available Weasel aircraft. McDonnell engineers never stopped trying to adapt the versatile Phantom to the Wild Weasel mission, and their efforts produced the Wild Weasel IV aircraft in the summer of 1969. Since the "new" F-4C Weasels were meant to supplement the F-105s, the Wild Weasel IV airplanes carried the same electronic sensors as the F-105 Weasels. The two aircraft differed mainly in their ordnance capabilities: the F-4C Wild Weasel IV was never configured to carry the AGM-78B Standard ARM. Thirty-six F-4Cs were modified to the Wild Weasel IV configuration, and the first Weasel IV arrived in Southeast Asia in October, 1969.[53] Because of the bombing halt over North Vietnam, the F-4C Weasels did not see combat until 1972.

During the Rolling Thunder bombing campaigns of 1965–68, AAA and AW fire were the primary threat to U.S. aircraft. Duels with MiGs and the SA-2 ranked second and third on the threat list, respectively. The air war over North Vietnam virtually ceased to exist between 1968 and 1972 because of the presidential directive forbidding aerial interdiction above the nineteenth parallel. When the North Vietnamese launched a massive invasion into South Vietnam in the spring of 1972, President Nixon authorized an intense retaliatory bombing campaign against North Vietnam known as Operation Linebacker I. However, improved munitions technology revised the order of the threat list to U.S. aircraft flying missions over North Vietnam.

Precision-guided munitions, such as the Hughes AGM-65 Maverick television-imaging missile, the Rockwell GBU-15 electro-optical-homing glide bomb, and the Texas Instruments KMU-351 Paveway I semiactive laser-homing glide bomb, brought destruction to North Vietnamese military targets while greatly reducing the risk of civilian casualties from stray bombs. The recently developed precision-guided munitions (PGMs) also reduced the risk to the American aircrews. Precision-guided munitions can be released from altitudes above five thousand feet, which thus limits exposure to AW fire and most AAA. During Operations Linebacker I and II, the surface-to-air missile became the primary threat to U.S. airmen, MiG interceptions remained a secondary threat, and AW and AAA fire became the lowest-priority hazard.

One could argue that the Wild Weasels and radar jamming aircraft failed during Operation Linebacker II—the "Christmas bombings" of Hanoi in December and January, 1972—because SAMs destroyed fifteen B-52 Stratofortresses. However, the ratio of SAMs fired to B-52s lost must be examined closely. No one is certain exactly how many SAMs were launched, but estimates range from 884 to 1,242 missiles. If one uses the more conservative figure, the SAM kill ratio for B-52s during Linebacker II was sixty-to-one.

More importantly, in the eleven-day campaign, Stratofortresses armed with chaff and ECM and escorted by Wild Weasel aircraft flew 724 missions and dropped twenty thousand tons of bombs on Hanoi and Haiphong.[54] Likewise, tactical bombers, such as the FB-111A, logged 640 sorties over Hanoi. Mission-support aircraft also completed 1,384 sorties during Linebacker II. Despite the intensity of the antiaircraft defenses around Hanoi and Haiphong, the United States military lost only twenty-six aircraft, and the SAM threat never led the airmen to abort a mission.[55]

After the war, the air force launched Project Red Baron III, an intense review and analysis of its performance in Southeast Asia. The Tactical Fighter Weapons Center at Nellis AFB compiled the study and concluded: "The main objective of the SAM system was to force US aircraft down to lower altitudes where they could be engaged by AAA forces. With an estimated nine SAM regiments, the NVNAF expended about 9,345 SAMs from over 200 locations to down 190 US aircraft (2% kill ratio). Over the years the SAM system was found to be vulnerable to jamming and air attack by US IRON HAND and Hunter-Killer aircraft."[56]

No one knows how many of the 191 American aircraft along with their pilots and crew members lost to surface-to-air missiles over North Vietnam might have been saved had the air force remembered the lessons of past conflicts and continued developing active and passive radar-suppression equipment and tactics. Likewise, countless aircraft and aircrews might have been saved had the air force remembered the lethality of anti-aircraft weapons and insisted that strikes be flown at altitudes above the range of the guns whenever possible. In all fairness, target restrictions and the rules of engagement also played a critical role in the loss of aircraft to AAA and AW, but those factors were beyond the Seventh Air Force's control. Moreover, aviation historian Anthony M. Thornborough notes, "At the close of hostilities in Vietnam, it was estimated that USAF losses over the North and Laos without Weasel or onboard self-protection systems would have been at least five times higher than those actually sustained."[57]

Fortunately, the Wild Weasel program also represents the beginning of the command-wide policy change. The air force realized in the summer of 1965 that corrective action must be taken immediately to reduce the SA-2 losses, and the Wild Weasel program commenced. Furthermore, the air force continued improving Wild Weasel electronics, ordnance, tactics, and crew training after American involvement in Southeast Asia ended. In 1975, the air force began flight testing the Wild Weasel V aircraft. The new Weasel incorporated the sophisticated APR-38 RHAW System (later upgraded to the APR-47), ALQ-119–17 (or ALQ-131) ECM pod, ALE-40 chaff/flare dispenser, APQ-120 navigation and fire-control radar, ARN-101 digital navigation and weapons delivery system, and the ASQ-91 weapons release computer into a standard F-4E airframe. The new Weasel, christened the F-4G, did not keep the F-4E's internal 20-mm cannon.

The APR-38 or APR-47 radar warning and attack systems constantly monitored flight data, the inertial navigation system, the fire-control system, and the status of available ordnance. The computer also observed a maximum of fifteen threats, displayed the distance and bearing of the potential threat to the aircraft, prioritized the threat, and selected the ordnance best suited to counter the threat. The Bear, of course, could override the computer and select the target and ordnance. The fifth-generation Wild Weasel aircraft carried a wide variety of radar-suppression missiles, including the AGM-88A High-Speed Anti-Radiation Missile (HARM), the AGM-78D Standard ARM, the AGM-45C Shrike, and the AGM-65D Maverick infrared imaging missile. For self-defense, the F-4G used both the radar-homing AIM-7M Sparrow and the infrared-homing AIM-9L Sidewinder air-to-air missiles.[58] Lastly, the F-4G used the "smokeless" J79-GE-17C engines, which did not produce the notorious twin plumes of black smoke so common to other F-4 models, and the G-model Phantom wing also used leading-edge slats to improve low-speed performance.

The air force did not stop with the development of the Wild Weasel V aircraft. The Wild Weasel EWO school became a twenty-five-week course, three times longer than the course for the first Wild Weasel crews in late 1965. The air force also designed and built the EF-111A Raven for tactical jamming and EC-130H Compass Call for standoff jamming. The F-4G thus performed the active radar-suppression mission, and the EF-111A and EC-130H served as passive radar suppressors. "We're a little lacking there" no longer applied to air force surface-to-air missile countermeasures.

CHAPTER 5

An Out-and-Out Crime

In his September, 1967, interview with Maj. Harry Shallcross, Capt. Leroy W. Thornal not only commented on how air force pilots were "a little lacking" when it came to training for the surface-to-air missile threat but also on how his instructors at George AFB were ill-suited to teach fighter combat tactics and maneuvering to the F-4 Phantom crews bound for Southeast Asia. Captain Thornal, who was credited with one probable MiG kill, stated

> As far as the MIG is concerned . . . I don't think that you have enough time to practice. I . . . think the training that we went through at George particularly inour [*sic*] case, is not qualified . . . to prepare us for really a going battle against the MIGs up there. Because the guys that we had, that came back to instruct us, used to be at one time, auto-interceptor [ground-controlled intercept] pilots that went over to Vietnam and Thailand and they became F—well they transitioned in the F-4—then they went over and they set up a night owl program over there which was a night bombing [operation], and then they came back to set up the school at George.[1]

Lieutenant Randy Cunningham, the naval aviator and the first American ace of the Vietnam War, agreed with Captain Thornal when he wrote: "When I went into combat I had over 200 simulated dogfights behind me. By way of comparison, in Da Nang, I met an Air Force C-130 pilot who had just transitioned to F-4s. He went through a total of 12 air combat training flights, then he was going up North to fight MiGs! I considered this situation an out-an-out crime."[2]

The expression "an out-and-out crime" accurately reflected the way the air force prepared many of its pilots for aerial combat over Southeast Asia. Basically, the Tactical Air Command neglected to train all of its fighter pilots for realistic air-to-air combat from the late 1950s until the summer of 1973. Instead of requiring student pilots to practice against aircraft comparable in performance to the MiGs that they would encounter over North Vietnam (such as the Northrop F-5 Freedom Fighter), Phantom pilots trained against other Phantoms. Dissimilar air combat training (DACT) was not used until after the war in Vietnam ended. How the U.S. Air Force abandoned the air-superiority mission after the Korean War and then resurrected it after the Vietnam War represents a third part to the command-wide policy reversal—and probably the most important part.

In order to truly understand fighter pilot training, one should first have a fundamental knowledge of fighter tactics. The tactics have changed little since Capt. Oswald Boelcke of the German Air Service first wrote what became known as the "Boelcke Dicta" in 1916. After the Korean War, General Blesse revised and expanded the Boelcke Dicta for aerial combat in the jet age in his article "No Guts, No Glory." Blesse's treatise became the standard reference manual for fighter pilots until the late 1960s when Lt. Col. John R. Boyd's Energy Maneuverability (EM) theory formally explained and defined the use of vertical maneuvers in aerial combat. Tactics such as the vertical rolling scissors, high–speed yo-yo, High–G roll-away, barrel-roll attack, are ideal for aircraft with poor maximum turn rates but with high thrust-to-weight ratios (i.e., the F-4 Phantom II). For an advanced, detailed examination of modern air-to-air tactics, the reader is advised to study either *Fighter Combat: Tactics and Maneuvering* by Robert L. Shaw or *Fighter Pilot Tactics* by Mike Spick.[3] Both authors, however, concede that nothing surpasses realistic fighter combat training—the more the better, too. As Shaw states, "The tactics to be employed in any conceivable situation must be predetermined and practiced so often that they become automatic."[4]

In the Korean War, American F-86 pilots scored a 10:1 kill ratio over MiG-15s flown by Chinese, Russian, and North Korean pilots. Midway through the Korean War, the Air Training Command headquarters at Scott Air Force Base, Illinois, analyzed the performance of F-86 pilots in Korea and concluded: "Although the MIG-15 aircraft is superior in many respects to the F-86, a favorable 7:1 kill ratio [as of May 1952] has been maintained in Korea, due primarily to the overall superiority of our pilots to that of the enemy. This fact alone emphasizes the importance of the quality of training in the Advanced Flying Programs. Probably the greatest single requirement in this type of training is that a realistic program be pursued commensurate with Flying Safety needs and available equipment."[5] During this same period, F-86 Sabre pilots chosen for the air-to-air mission (as opposed to air-to-ground) received eighteen hours and twenty minutes' worth of flying practice in air-to-air gunnery and thirty-one hours and twenty minutes' worth of flying practice in air-combat tactics.

The October, 1952, training syllabus specified that F-86 air-superiority pilots fly eight air-to-air gunnery missions at an altitude of 15,000 feet, ten missions at 20,000 feet, and three missions at 30,000 feet. A final air-to-air gunnery practice mission was also scheduled to correct any deficiencies, and each gunnery mission was programmed to last for fifty minutes. The air combat tactics portion of the syllabus called for two acrobatics practice sorties, four tactical formation missions, three ranging and tracking practice flights, eight fighter versus fighter engagements, four interceptor flights, and two bomber escort missions. Each of the twenty-three air-superiority training sorties required between fifty minutes to an hour and twenty minutes to complete, and the mission altitudes also ranged from 25,000 to 40,000 feet.[6] Without a doubt, an F-86 pilot who successfully completed the above requirements possessed a thorough knowledge of the Sabre as a fighter weapons system, and a ten-to-one kill ratio cannot be ignored.

Operation Sage Brush, a joint army–air force training exercise conducted in 1955, marked TAC's departure from its emphasis on air superiority. The exercise simulated a nuclear battlefield across the southern United States. Caroline Ziemke describes Operation Sage Brush as a product of TAC's efforts "to develop a unique mission for itself within the context of massive retaliation, independent of its relationship with the army, and beyond the operational scope of SAC."[7] Each side in Operation Sage Brush controlled its own air force and army, and both sides used simulated tactical nuclear weapons against the other. Among other things, the exercise showed the awesome destructive power produced by tactical nuclear weapons, especially when they were delivered by a single F-100 fighter-bomber flying below the effective altitude for the early warning radar stations. General Bruce K. Holloway, a former fighter pilot in Maj. Gen. Claire L. Chennault's American Volunteer Group of World War II (the famous "Flying Tigers") commented after the conclusion of the exercises, "the concept of interdiction and close air support becomes quite obscure, and drastic revision of tactics and methods of operation . . . are necessary."[8]

Some of the air force participants, such as General Holloway, finished the exercise with a renewed belief in the need for a well-trained fighter force, stating, "Complete air superiority is even more necessary than it has been in the past."[9] Unfortunately, that opinion was in the minority. Most participants concluded that swift destruction of the enemy's offensive capability and not control of the air was the key to victory in the atomic age. When asked what major tactical lessons were learned from Sage Brush, Brig. Gen. Eugene H. Underhill, commander of the fictitious "Sixth Air Army," replied: "The necessity for completely grounding the hostile air force. Air superiority is now an almost meaningless term. In order to insure our capability for continuing air operations the hostile atomic striking force must be grounded."[10] Nuclear interdiction thus became TAC's focus. In 1960, the air force's *Fighter Weapons Newsletter* plainly stated: "The primary mission of the tactical fighter is the delivery of weapons, either nuclear or high explosive ordnance. William Tell 1960 [a biennial, Air Force–wide, air-to-air competition] demonstrated to the World the capability of the Tactical Fighter [*sic*] in accomplishing the mission by close air-ground support of troops, interdiction of enemy targets, and TAC's capability for air-to-air offense or defense."[11]

A survey of fighter-pilot training syllabi from the 1960s further illustrates the emphasis given to interdiction bombing as opposed to air-to-air combat. For example, two tactical fighter squadrons from the Twelfth Air Force continually rotated through the Fighter Weapons School at Nellis Air Force Base, Nevada, for a month-long refresher course designed "to keep the TAC squadrons abreast of the latest weapons delivery techniques, and to increase their proficiency in the tactical fighter mission."[12] The three-week-long refresher course called for 11 air-to-ground ordnance practice flights (6 for nuclear weapons, 4 for conventional weapons, and 1 GAR-8 missile firing) and only 4 air-to-air sorties.[13]

As the war in Southeast Asia escalated during the mid-1960s, the fighter-training syllabi of 1965 should have been revised to provide realistic air-combat maneuvering (ACM) training to the men who would soon be engaging the small, agile North Vietnamese MiGs. The following table lists the number of air-to-ground training sorties (using both nuclear and conventional weapons) and the number of

Table 7.
Comparison of Training Sorties Flown in 1965

Aircraft	Course Number	Type of Training	Air-to-Ground Sorties	Air-to-Air Sorties
F-105	111106E	Operational	22	14
F-105D/F	111506E	Operational	13	4
F-100	111505B	Figher Weapons Instructor	23	12
F-105	111505E	Fighter Weapons Instructor	23	12
F-4C	111505F	Fighter Weapons Instructor	17	10

Source: Data from *History of the 12th Air Force,* 99–106.

air-to-air practice missions flown by the students. The data clearly demonstrate that TAC continued concentrating on interdiction and gave only modest attention to air-superiority training. This fact is most obvious in the F-4C Fighter Weapons Instructor syllabus. When reviewing the data from table 7, remember that it was the F-4 Phantom crews who were assigned to escort the bomb-laden F-105 Thunderchiefs to their targets in North Vietnam and then to perform either Barrier Combat Air Patrol (BarCAP) or MiG Combat Air Patrol (MiGCAP) for the strike force.[14]

In 1952, F-86 pilots received at least forty-five air-to-air training flights and the final Sabre-to-MiG kill ratio in Korea was 10.15:1. In comparison, the final USAF-to-MiG fighter aircraft kill ratio from 1965 to 1973 was a dismal 2.21:1. The air force lost 40 F-4s, 1 F-102, and 21 F-105s in air-to-air combat for a total of 62 fighters, whereas the North Vietnamese lost 61 MiG-17s, 8 MiG-19s, and 66 MiG-21s—a total of 135 fighter aircraft—to the combined efforts of the air force, navy, and Marine Corps.[15]

General Daniel "Chappie" James, Jr. argued vehemently for a return to the standards of the old syllabus when air-to-air gunnery was mastered before an air force pilot was awarded his silver wings. In a 1977 interview, General James stated that the new pilots "came to us in combat crew training in the F-4s at Davis-Monathan AFB, a lot of guys [who] had really burned up the course coming through

UPT [Undergraduate Pilot Training]. . . . When we got into the [target] dart business and had them out there trying to hit something that was moving around and maneuvering in the sky, you have never seen so many guys who didn't even come within the same county. You ask him how far you think he was before he fired that burst, and he would say 1500 feet, and he was probably 2–1/2 miles [*sic*]."[16]

Three other factors also contributed to the demise of air-combat training: safety issues, the development of the interceptor aircraft, and faith in long-range air-to-air missiles. Realistic air-combat training is a dangerous activity: the pilot is flying the airplane to the edge of its performance envelope, and pilots and airplanes will occasionally be lost in the process.[17] Unfortunately, the air force placed more emphasis on its capital equipment throughout the late 1950s and 1960s than it did on preparing its pilots for aerial combat. Moreover, the air force rewarded the squadron commanders who "played safely." As Lt. Col. Douglas Campbell remarked, "Regardless of whether the mishaps involved supervisory error, those who commanded squadrons with exceptional safety records were generally promoted ahead of commanders whose units lost aircraft in training accidents."[18]

The *History of the United States Air Force Fighter Weapons School (TAC) and 4525th School Squadron (Tactical Weapons)* illustrates the extreme emphasis placed on safety in the early 1960s. The Fighter Weapons School at Nellis Air Force Base was created in the aftermath of World War II. Its mission was, and still is, "to train selected tactical fighter pilots [usually the most proficient pilots in a squadron] to qualify as fighter weapons delivery instructors. When graduates return to their parent unit they will function as fighter weapons delivery instructors."[19] Volume 3 of the January 1–June 30, 1961, history records a typical training accident and how it affected ACM training. The report states that the "Death of Captain Garneau, while flying an ACM mission, resulted in cancellation of the remainder of the ACM flying program for [Class] 62-A. Failure to receive the laboratory (flying phase) training caused subsequent lowered appreciation for the academic training in the subject (as indicated in the class critique)."[20]

Training-related deaths are especially regrettable, but such incidents must not be permitted to cause the degradation of vital operational training. The fact remains that the graduates of Class 62-A left the Fighter Weapons School unprepared to instruct their fellow pilots in the demanding art of aerial combat. How could the members of

Class 62-A become effective fighter weapons instructors if they themselves did not fully grasp the subject because the loss of a pilot and an airplane ended their ACM training?

Senior air force and navy leaders in the late 1950s and early 1960s did not fully understand the performance characteristics of their new supersonic fighters and reacted with excessive caution to the control problems that resulted from a swept-wing or delta-wing configuration. Captain Thornal strongly criticized this unreasonable emphasis on safety and then commented on its effects in the Vietnam War when he remarked that the air force had "sort of shied away from" realistic air combat training "for safety['s] sake back in and after the Korean War. Get away from this wild hassle in the air, lets [*sic*] worry about safety. And this is the area we need it [training] now up there to hassle with the MIGs."[21]

The F-4 Phantom's adverse yaw departure problem led TAC to impose further restrictions on ACM training. The following scenario related by Col. Phil Handley represents what typically occurred in many F-4 outfits throughout the 1960s.[22]

Two aggressive F-4 crews would be engaged in a practice dogfight. As one crew tried desperately to obtain a firing position on the other, it encountered departure. Despite his best efforts, the pilot could not recover the airplane, and both crewmen had to eject. The accident review board determined that the pilot lost control of the aircraft while performing a six-g turn at a high angle of attack. The board, searching for ways to prevent further losses, suggested that the F-4 be restricted to four-g maneuvers. Tactical Air Command concurred with the recommendation and an appropriate restriction would be issued to all fighter squadrons.

Shortly after the first accident, two different Phantom crews were engaged in a practice air-to-air combat mission. While executing only a two-g turn (but at low airspeed and a high angle of attack), one of the aircraft would depart, forcing its crew to eject. Although the pilot of the destroyed aircraft was well within the permissible g restrictions, the high angle of attack coupled with the F-4's tendency to yaw led to its departure from controlled flight. The accident review board would then propose restricting Phantom pilots from exceeding a specific angle of attack. Phantom crews thus were required to train for aerial combat using a flight regimen confined to unrealistically high airspeeds and low angles of attack.

Granted that these restrictions saved several multimillion-dollar aircraft, they also reduced the combat readiness of those who flew the air force's primary tactical fighter aircraft. Instead of flying the Phantom to the edge of its performance envelope, as they would in the skies over North Vietnam, many F-4 pilots were only allowed to fly the proverbial "gentle circles around the base flagpole." A boxer who does not spar when training for a title match probably will be knocked out early in the fight because his timing and technique will be off. Likewise, fighter pilots forced to adhere to excessive safety restrictions in practice engagements can hardly be expected to achieve the level of expertise required to sweep the skies of enemy aircraft.

The manner in which the air force crewed its Phantoms created a similar problem to the one described above. In the air force, Phantom pilots rarely flew with the same WSO on a regular basis. Pilot/WSO pairings changed frequently, which reduced aircrew coordination and weapon-system effectiveness. No respectable football coach would ever play a game without knowing for certain that the center had practiced snapping the football to the quarterback during the pregame preparations, yet the air force expected pilot/WSO teams to work together in a combat environment without having practiced together on a routine basis. To its credit, the navy kept its pilot/radar intercept officer teams together throughout each cruise.

It must also be noted that Wild Weasel pilots and EWOs were pared before their training began and remained together as a team throughout their tour of duty. Colonel Broughton explained that when pilots and EWOs "arrived for Weasel school at Nellis they had a dating game cocktail party where the front seaters and GIBs choose [*sic*] each other, and they stayed together throughout school and combat. Only in a rare emergency would they fly with someone else."[23]

The development of beyond-visual-range air-to-air missiles not only forever changed fighter and interceptor design, but it also had a very negative impact on air-combat training. From the end of World War II until the collapse of the Soviet Union, the greatest perceived threat to American security was a nuclear war with the Soviet Union. The United States and other North Atlantic Treaty Organization (NATO) nations feared sudden destruction from waves of intercontinental ballistic missiles armed with multiple nuclear warheads and from atomic bombs dropped by massed formations of Soviet strategic bombers. Furthermore, the Soviet-designed MiGs were "point-defense interceptors" with very limited range. The MiG designers gladly traded range for maneuverability, and the Soviet Air Force never developed a practical aerial refueling system. Thus, the Soviet long-range strategic nuclear bombers would be forced to fly to their targets in Europe and America without fighter escort.

Intercepting and destroying an unescorted heavy bomber with a radar-guided missile is a much simpler task than dueling with another aircraft of equal or better maneuverability. All one has to do is become airborne, climb to the altitude of the bombers, select the appropriate missile, obtain a radar lock on a bomber, and pull the trigger. The AIM-7 Sparrow radar-guided missile used in Vietnam had a range of several miles at high-altitude and was designed to destroy enemy bombers at ranges where guns would be totally useless. The Sparrow missile thus made it possible for Phantom crews to focus on the interceptor mission at the expense of the air-superiority mission. This problem was not unique to the air force: Cmdr. John Nichols observed that the "F-4 squadrons, being state-of-the-art in equipment and doctrine, seldom bothered with 'outmoded' pastimes such as dogfighting. Besides, they had no guns and consequently felt little or no need to indulge in ACM."[24] David Fuller, a radar intercept officer who flew the backseat in Marine Corps F4s, said: "We were fortunate because we were very experienced in the Phantom before we went to Vietnam. I would guess that the average [time in the F4] must have been about 500 hours per crew, so we really knew the airplane. Unfortunately, all of that time had been spent practicing the interceptor mission."[25]

The record of the navy's F8 Crusader in aerial combat over North Vietnam provides a good example of what should have happened in the Vietnam War had the "interceptor mentality" not prevailed throughout the military. Designed in 1953, the Vought Crusader was a contemporary of the F-100 Super Sabre. Both aircraft used the Pratt and Whitney J-57 afterburning turbojet engine, but the Crusader's empty weight was about forty-five hundred pounds less than the Super Sabre. Consequently, the Crusader's outstanding maneuverability made it the "MiG Master" of Southeast Asia while the Super Sabre never saw air-to-air combat in the Vietnam War.

The Crusader was a demanding aircraft to fly, and landing one aboard an *Essex*-class aircraft carrier was especially difficult. With an accident rate of 46.70 per hundred thousand flight hours, the F8 owns one of the worst safety records of any U.S. tactical aircraft. By comparison, navy F4 Phantoms had an accident rate of 20.17 per hundred thousand flight hours.[26] Admiral Paul Gillcrist, a former navy test pilot who has flown every navy fighter from the Grumman F6 Hellcat of World War II to the modern Grumman F14 Tomcat, wrote that "the F8 did not score high on flyability. . . . The post-stall gyration and spin characteristics were absolutely awful. Spin recovery procedures differed for different kinds of spins."[27] Despite these difficulties, however, the F8 achieved an exemplary 6:1 confirmed kill ratio—the best U.S. fighter exchange ratio of the Vietnam War. Between 1966 and 1968, Crusader pilots scored eighteen confirmed MiG kills and three probable kills, while North Vietnamese pilots succeeded in downing only three Crusaders.[28]

Given the fact that Crusader pilots flew the exact same missions as their Phantom counterparts, how did Crusader pilots achieve a 6.0:1 MiG kill ratio while navy Phantom pilots earned a 5.42:1 kill ratio? The navy F4 kill ratio statistics can be further reduced if one considers only the period from 1965 to 1968 (the years that the F8 was in frontline service in Vietnam) when navy F4s downed just thirteen MiGs. Also consider the fact that air force Phantoms achieved a 3.07:1 MiG kill ratio for the entire Vietnam War.[29]

The answer to this question lies in the Crusader's weapons systems and the impact that it had upon pilot training. The F8's offensive weaponry consisted of four 20-mm fuselage-mounted cannons with a maximum of 150 rounds of ammunition per gun and either two or four AIM-9 Sidewinder missiles (depending on the F8 model). The gun-feeding mechanism was prone to jamming while being fired in high-g maneuvers, so most Crusader squadrons carried only sixty rounds per gun to reduce the risk of a malfunction. The F8 was never equipped to carry the AIM-7 Sparrow missile, and it is this fact that is crucial to the Crusader's success in the Vietnam War.

While navy F4 Phantom pilots spent most of their ACM training time practicing head-on intercepts with the radar-guided Sparrow missile, F8 Crusader pilots were forced to hone their conventional dogfighting skills since both the gun and the Sidewinder missile are not very effective in head-on intercepts. Furthermore, the gun on the Crusader also facilitated many of the Sidewinder kills. According to Adms. Paul H. Speer and Paul Gillcrist: "Although the gun never killed many MiGs in the southeast Asian air war, having it was critical. The most deadly tactics were always to maneuver aggressively for a gun kill. While so doing, the Crusader pilot usually passed through the heart of the envelope for a Sidewinder shot and took it. . . . Having the gun enabled the Crusader pilot to stay aggressive throughout the engagements . . . and to stay alive!"[30]

With few exceptions, North Vietnamese MiG pilots usually fled the area once an American pilot committed to an engagement. A short burst from the cannon of either an F8 or an F-105 would often force a hostile MiG to disengage, which would then move the retreating MiG into the envelope for a Sidewinder missile. In fact, on May 23, 1972, a MiG-17 pilot chose to eject immediately before Lt. (j.g.) Gerald Tucker could maneuver his F8 into firing position.[31] Aviation historian Barrett Tillman concluded that "Crusaders seldom fired their guns in air combat, but the very fact that they had four 20 mm guns provided a peacetime training stimulus to remain proficient in air combat maneuvering."[32] The Crusader statistics clearly show that ACM training made the difference in aerial combat, and TAC's senior leaders eventually relearned this valuable lesson as the air war in Vietnam entered its final stage.

In August, 1972, Seventh Air Force asked F8 pilots from the USS *Hancock* to teach fighter tactics to its pilots. Commander Nichols was one of the Crusader pilots assigned to teach ACM to the air force pilots, and he describes his experiences as follows: "In August 1972 the chief of staff in *Hancock* summoned me. 'We have a request for F-8 pilots to fly with the air force and teach them tactics. Just be tactful.' And away we went. I had two pilots from VF-211 and another from VF-24. On arrival at Udorn I was driven to a general's office and he said, in effect, 'We used to know this stuff, but we forgot it. We haven't taught it in years. We believed those days were over. I'm afraid we didn't keep the faith.' He was right."[33] In fairness, many air force fighter pilots during that same period had indeed "kept the faith." Across TAC as a whole, however, air-combat maneuvering was a forgotten art.

As part of the Project Red Baron III postwar analysis of air-to-air encounters in Southeast Asia, the air force performed an extensive statistical study of several hundred "decisive" engagements (ones in which either the U.S., the North Vietnamese, or possibly both aircraft were lost). The variables in the study included the pilot's prior flying time, prior combat experience, level of ACM training, age, and formation position at the time of the engagement. The results of the study showed that "the factors which most definitely influenced the outcome of decisive engagements were (1) the pilot's prior ACM training, and (2) the pilot's flight position."[34]

The Project Red Baron III staff members also interviewed 290 TAC fighter pilots who had participated in an engagement with a MiG in which some form of ordnance was fired at the enemy aircraft. The MiG encounters in this particular survey occurred during the 1971 to 1973 period. When asked, "What factors contributed most to a US pilot's ability to *achieve* an offensive posture in an air-to-air encounter?" the pilots ranked "Training and Experience" second only to "Warning and Detection."[35] When asked, "What factors con tributed most to a US pilot's ability to *maintain* an offensive posture in an air-to-air encounter?" the pilots listed "Training and Experience" as the most important factor.[36] Lastly, when asked, "What concepts should the USAF stress in preparation for future air-to-air conflict?" the fighter pilots placed an equal emphasis on both "Training and Experience" and "Aircraft Performance."[37] After reviewing the statistical analysis of the MiG encounters and the results of the pilot surveys, the Project Red Baron III committee members recommended that the air force provide "intensified ACM training for all tactical fighter pilots who can reasonably expect to be involved in air-to-air combat in any future conflict."[38]

In the summer of 1972, Maj. Gen. William P. McBride, the TAC deputy chief of staff for operations, formally acknowledged in a memorandum to Gen. William Momyer, the TAC commander, that "Recent combat operations in the conflict in SEA [Southeast Asia] have highlighted the lack of knowledge and proficiency in aerial combat of F-4 aircrews. Recent reports from Commanders and Operations personnel in SEA have specifically identified a requirement for additional ACT [Air Combat Tactics], particularly, ACT training with more than four aircraft simulating current hit and run tactics."[39] In response, the air force chartered an Air-to-Air Capability Action Group now that air superiority had become "an item of command interest."[40]

Colonel Donald E. Miller, the air force director of flight operations, listed seventeen programs to improve TAC's air-to-air capability in a memorandum to General Momyer. Along with the quarterly *Fighter Weapons Review* from the Fighter Weapons School at Nellis AFB, the air force began publishing the "TAC Tactics Bulletin" to "disseminate current tactics on a timely basis."[41] Instructors from the Tactical Fighter Weapons Center visited many operational TAC units, Replacement Training Units (RTUs), Combat Crew Training (CCT) squadrons, and selected Air National Guard squadrons to discuss fighter tactics.[42] To no one's surprise, the instructors reported that "tactics dissemination within TAC was poor to non-existent."[43] Furthermore, TAC aircrew proficiency was now evaluated in the air-to-air role, and the Fighter Weapons School conducted a "Top Off" course. In the Top Off program, select air force F-4 crews bound for Southeast Asia received an intense two week-long course in fighter tactics. Unfortunately, the first Top Off graduates did not arrive in the theater until just before the air war over North Vietnam ended. Shortly after the war, the Top Off syllabus was incorporated into the regular RTU/CCT programs.

In another significant revision, the air force added nine air-to-air training sorties to the F-4 RTU/CCT long-course syllabus. Phantom pilots bound for Vietnam in the early 1970s received a total of twenty air-superiority training flights. Those F-4 pilots who trained under the revised syllabus, however, received eight additional ACM practice sorties and one live-fire exercise with an AIM-9E against a target drone.[44]

The Tactical Air Command also began dissimilar air-combat training in the fall of 1972 at both Tyndall AFB, Florida, and at Nellis AFB. At Tyndall AFB, F-4E crews flew a total of thirty-six air-to-air sorties against F-106 interceptors, and F-4 Phantoms challenged T-38 supersonic trainers at Nellis. Although the F-5E would have been a better MiG-21 simulator than the T-38 and especially the F-106, it was not readily available. The dissimilar air combat training at Tyndall AFB was unrealistic for another reason: the Air Defense Command's F-106s employed U.S. tactics instead of Soviet-style tactics based around an extensive ground control intercept radar network. Tactical Air Command quickly realized that its pilots needed more realistic training if they were to be successful in the next war, and thus "Redland" was built.

After several years of determined effort, Col. Richard M. Suter persuaded TAC commander Gen. Robert J. Dixon in 1972 to establish the most realistic air-combat training program possible. General Dixon agreed with Colonel Suter's arguments, and in 1975 the air force created both the fictitious "people's republic" of Redland and the 64th and 65th Aggressor Squadrons at Nellis AFB. Redland covered three million acres of the Nevada desert, and pilots from the former Aggressor Squadrons along with the imaginary 108th Guards Tank Army protected it from the invading "Yankee air pirates."[45] The

Aggressors employed Soviet fighter tactics in their F-5E and T-38 aircraft to simulate MiG-21s and MiG-23s. Later, the Aggressors squadrons switched to the F-16C to imitate the MiG-29 and Su-27. Redland's industrial complex (a series of wooden buildings held together with baling wire), oil pipeline (telephone poles painted white and laid end-to-end), and railroad network was guarded by thousands of armored vehicles, SAMs, radar-guided AAA, and AW. Redland also featured simulated air bases with surplus aircraft parked along the flight line. Six times a year, the air force declared a six-week-long war against Redland in an operation known as Red Flag.

In the Red Flag exercises, units from throughout the air force (and sometimes the U.S. Army and U.S. Navy), NATO, and the air forces of other American allies come together to attack Redland. Although the 64th and 65th Aggressor Squadrons were disbanded in 1990 because of defense budget cuts at the end of the Cold War, many former Aggressor pilots joined the 414th Composite Training Squadron and continued flying Soviet fighter tactics. Unlike the navy's Fighter Weapons School at Miramar Naval Air Station, California (better known as Top Gun), Red Flag gives its pilots realistic experience in a "total force" situation. For example, an F-15C fighter wing assigned to fly MiGCAP for F-16C tactical strike aircraft in a typical Red Flag mission must coordinate its activities with the tactical strike force, the KC-10 and KC-135 tankers, E-3B/C Sentry Airborne Warning and Control (AWACs) aircraft, and EC-130 Compass Call electronic countermeasure aircraft. The MiGCAP flight must also evade simulated surface-to-air missiles, radar-guided AAA and AW, and protect the strike force from MiGs. The navy's Fighter Weapons School, by comparison, teaches its students how to be experts in air-combat maneuvering and fighter tactics in a challenging five-week-long course. Furthermore, only the best naval aviators and weapons system operators from each squadron attend the navy's Fighter Weapons School, whereas Red Flag involves entire squadrons.

That Red Flag exercises are expensive is undeniable, but the results generated by such a realistic training program became readily apparent in Operation Desert Storm. During the brief war in Kuwait and Iraq, air force F-15C Eagles downed thirty-four Iraqi aircraft (this figure includes three Iraqi helicopters) without a single air-to-air loss.[46] Lieutenant Colonel Ronald Wallace, the deputy commander of the 554th Range Squadron at Nellis, commented: "We had crews return from Desert Storm who said the war was a piece of cake compared to Red Flag. That's what it's all about for us. We train our aircrews here so they won't have to train in battle. This is a one-of-a-kind asset that provides realistic, composite force training—including training with our allies. And it's proven its value over and over again. When they leave here, they're ready for combat."[47]

The aggressor concept—a unit assigned to copy enemy tactics and strategies for realistic training—was not a new idea. In a 1948 thesis presented to the Air Command and Staff School of the Air University, one officer proposed that the air force develop an aggressor air force because the "history of training in the United States Air Force is characterized by a lack of realism."[48] After detailing how such an organization could be created, the officer then concluded his thesis by stating that "timely development and employment of an Aggressor Air Force will provide the United States Air Force with a sound practical training aid of unprecedented importance in preparing it to enter combat at any time against potential enemies of the United States of America."[49]

The Tactical Air Command started another successful fighter pilot course in 1973 known as the Lead-In Fighter Training Program. Prior to 1973, an air force fighter pilot completed the undergraduate pilot training course in the subsonic T-41 and T-37 and finished his undergraduate training in the supersonic T-38 aircraft. The student pilot was then transferred to combat crew training where he transitioned directly into his assigned fighter or attack aircraft. During combat crew training, the novice aviators learned to fly the most sophisticated fighter and attack aircraft in the air force inventory as well as basic fighter maneuvers and advanced air-combat maneuvering. The combat-crew training phase could be overwhelming for a new pilot.

Instead of sending the novice aviators directly into combat crew training, TAC decided to teach basic fighter maneuvers (BFM) and advanced air-combat maneuvering in the familiar T-38 Talon at the Lead-In Fighter Training Program. Teaching BFM and advanced ACM in the T-38 allowed the freshman pilots to focus on learning how to dogfight instead of how to fly a sophisticated aircraft with its complicated weapons systems. The Lead-In Fighter Training Program also saved money: In 1975 the average total cost per flying hour for a T-38 was $319 versus $1,215 for an F-4. It thus cost nearly 75 percent less to train in the T-38 than the Phantom. Lastly, the Lead-In Fighter

Training Program served as a force multiplier for TAC. The new training program released fighter and attack aircraft from combat crew training for use in operational squadrons.[50]

The syllabus for the Lead-In Fighter Training Program came directly from Fighter Weapons School publications and from the combat crew training units. The 465th Tactical Fighter Training Squadron at Holloman AFB, New Mexico, conducted the six-week course. The student pilots received three days of classroom instruction and twenty-five days of practice flying. Eight of the nineteen training sorties and seventeen of the forty-two classroom hours were devoted solely to air-to-air combat tactics and maneuvers.

Lead-In Fighter Training was not, however, a novel idea in the postwar air force. As early as June, 1967, new F-105 pilots began receiving twenty hours of instruction in aerobatics, formation, and gunnery in the AT-33 from the pilots of the 23rd Tactical Training Division (TTD) at McConnell Air Force Base. Lieutenant Colonel Richard A. Braven, commander of the 23rd TTD, summarized the program as follows: "The AT-33 lead-in program remains an economical and safe method of increased flying and weapon delivery proficiency prior to F-105 training. It must be pointed out clearly, however, that the force behind this program depends upon having instructor pilots who are also instructor pilots in [the] F-105 or who at least can rely upon past fighter bomber experience."[51]

Remembering what Captain Thornal said about his F-4 Phantom instructors at George AFB in 1966, it is interesting to note the emphasis that Lieutenant Colonel Braven gives to having qualified instructors for the F-105 Lead-In Fighter Training Program. Moreover, why TAC waited until after the Vietnam War to start such a program for its F-4 aircrews remains a mystery.

A decade after TAC implemented programs such as Lead-In Fighter Training, Red Flag, Aggressor squadrons, and dissimilar air-combat training, the air force observed two startling results: pilot proficiency had increased and the accident rate had significantly *decreased.* During the 1970s, the average Class A accident rate (loss of aircraft) held at 5.1 mishaps for every hundred thousand hours of flying time. By the 1980s, the average Class A accident rate had fallen to 3.5. General John M. Loh, the last TAC commander before it merged with SAC and became the Air Combat Command, credited the improved safety record to better pilot training: "as TAC emphasized more realistic and better formal aircrew training programs, the mishap rate fell further. Programs like Red Flag, the Aggressors, low-level and composite force training improved our combat capability and our ability to fly safer."[52] Sadly, only a dedicated few had truly realized the importance of realistic air-combat training until a grim 2:1 MiG kill ratio over North Vietnam shook TAC out of its slumber.

CHAPTER 6

The Eagle Soars

THE AIR FORCE BEGAN LOOKING FOR A successor to the F-4 Phantom in April, 1965. In response to the "Fighter-Experimental" (F-X) project request, the Air Force Systems Command proposed a variable swept wing fighter that weighed between sixty thousand and sixty-two thousand pounds, had a wing loading of about 110 pounds per square foot, and flew at Mach 2.7. The F-X, like its predecessor the F-105 Thunderchief, was designed primarily as an air-to-ground fighter-bomber with air-to-air capabilities, but it was physically impossible to achieve the degree of maneuverability needed to duel with a MiG from such a massive airframe. The proposed single-engine F-X aircraft would have been at least four tons heavier than the F-105, and its wing loading would have been almost 20 percent more than the Thunderchief's combat wing loading value.

Fortunately for the air force, several events transpired that caused TAC to lose interest in the proposed new fighter, foremost of which was the strong opposition from the "Fighter Mafia." The "Fighter Mafia" was a select group of men that included Maj. John Boyd (developer of the energy-maneuverability theory), Col. William Ritchie (Boyd's commanding officer), Gen. Kenneth C. Dempster (chairman of the committee that created the Wild Weasel program), and civilian consultants Pierre Sprey, Harold Hillaker, Thomas Christie, and Everest Riccioni, all of whom demanded that the F-X's weight be significantly reduced to improve its maneuverability. After much debate, TAC commander Gen. Gabriel P. Disosway insisted that the F-X should weigh forty thousand pounds and not a pound more because "if you let the plane go one pound over, it was like opening Pandora's box. The first pound won't hurt much and the next one won't hurt, but then every pound you go over becomes easier and the next thing you know, you've altered the design."[1]

The air force also heard rumors that the navy's new fighter design—the "Navy Fighter–Experimental" (VFX), which eventually became the F14 Tomcat—weighed in at less than fifty thousand pounds. If the rumors were true, TAC knew that neither the air force Office of Systems Development nor the U.S. Congress would appropriate funds to develop a sixty-thousand-pound air-superiority fighter. The air force decided to abandon the proposed F-X design and try again. Maj. John Boyd later estimated that between three hundred and four hundred different design configurations were studied before a suitable one was selected.[2]

The F-X program changed dramatically when the air force decided to appease Defense Secretary McNamara by evaluating the navy's A7 Corsair II as a potential successor to the A-1D Skyraider, F-100 Super Sabre, and F-105 Thunderchief. Few in either the air force or navy believed that a subsonic aircraft could survive combat operations over North Vietnam. Originally designed as the replacement for the A4 Skyhawk, the A7 was subsonic for several reasons. Compared to a supersonic attack aircraft, the slower airspeed gave the Corsair a greatly increased range and loitering capability, better maneuverability, simplicity of maintenance, and cost (one supersonic airplane typically costs approximately as much as three similar subsonic airplanes). Three air force pilots were selected to accompany navy attack squadrons VA-146 and VA-147 aboard the USS *Ranger* for the Corsair's first combat cruise. To the astonishment of many, the two squadrons flew approximately three thousand sorties without losing an airplane.[3]

After the A7 had proved itself in combat, the air force reluctantly decided to purchase it, but only after Vought had made many substantial modifications. The new model, which the air force designated A-7D, flew more than four thousand sorties over Southeast Asia, yet only four aircraft were lost in combat.[4] The air force's decision to purchase the A-7D was crucial to the F-X program because the slow, heavily loaded Corsair needed fighter escort to protect it from MiGs. Tactical Air Command found itself in dire need of a true air-superiority aircraft. According to Major Boyd: "When the A-7 came out it impacted heavily on the F-X; it turned it around from being primarily air-to-ground with an air-to-air secondary to a primary air-to-air, air-to-ground secondary. I think that was the contribution the A-7 had in terms of how the F-X was going to be laid out."[5] The decision to acquire the A-7 Corsair II thus compelled the air force to design its first true air-superiority aircraft in two decades. The debut of the MiG-25 at the 1967 Domodadovo air show provided even more incentive for a new fighter with low wing loading and a high thrust-to-weight ratio.[6] In September, 1968, the air force issued a Request for Proposal, and on December 23, 1969, McDonnell Douglas was selected to build the F-15 Eagle.

The slogan for the Eagle's design team spoke volumes about its design philosophy: "Not a pound for air to ground." In its effort to design the best possible air-superiority aircraft, McDonnell Douglas evaluated some twenty-two different combinations of variable-sweep and fixed-sweep wings using both pod-mounted and fuselage-mounted engines. Eight hundred different wing plan forms were designed and 107 airfoils were tested in a wind tunnel. Before the F-15 made its first flight, McDonnell engineers had spent a total of 22,188 hours performing wind-tunnel tests and 2.5 million man-hours in design. By way of comparison, the F-4 Phantom design was approved after only 4,287 hours of wind tunnel testing.[7] The final F-15 wing was designed with a maximum lift-to-drag ratio for best maneuvering performance and not for best cruising airspeed: the Eagle was a fighter, not an interceptor.

The F-15A was 63 feet 9 inches long, 18 feet 7.25 inches high, and had a maximum wingspan of 42 feet 9.5 inches, which gave it a wing area of 608 square feet. Its two Pratt and Whitney F-100-PW-100 engines each produced 14,870 lbst and 23,810 lbst with the afterburner engaged. The F-15A had a gross weight of 41,500 pounds, an empty weight of 27,581 pounds, and a typical combat weight of 40,000 pounds, which gave it a remarkable combat wing loading of only fifty-four pounds per square foot. The combat thrust-to-weight ratios were equally impressive: 0.907 (1.450 with afterburner) at mean sea level, and 0.342 (0.548 with afterburner) at an altitude of thirty thousand feet.

The Eagle cruised at 495 knots, and its maximum airspeed at 36,000 feet was Mach 2.5 (1,433 knots).[8] Like its predecessor, the F-4 Phantom, the F-15 set many performance records, especially with its ability to climb to an altitude of 40,000 feet in one minute. The aircraft that set most of those time-to-climb records was an unpainted preproduction model F-15A with all nonessential equipment removed. This particular airplane, known as the "Streak Eagle," could climb to 60,000 feet faster than the Saturn V rocket from the Apollo space program.[9] The F-15A's service ceiling was sixty-five thousand feet, and its internal fuel capacity of 1,714 U.S. gallons gave it a range of 2,878 miles without refueling.

Along with its complement of four radar-guided AIM-7 Sparrow missiles and four infrared-guided AIM-9 Sidewinder missiles, the F-15A also carried an internal M61A1 20-mm Vulcan cannon and 940 rounds of ammunition.[10] The F-15 was, without a doubt, an air-superiority fighter in the tradition of the P-51D Mustang and the F-86 Sabre. Like the two legendary fighters from the past, the Eagle was even designed with a teardrop-shaped Plexiglas canopy that gave the pilot unrestricted visibility in all directions.

The difficulties air force Phantom pilots and WSOs experienced coordinating their efforts led the service to insist that the F-15A be designed around a single crewman. Conversely, the navy's satisfaction with the pilot–radar-intercept-officer concept was reflected in the two-man design of the F14 Tomcat, its successor to the F4. Significant advances in automation technology and in cockpit displays also convinced the air force that a lone pilot could successfully operate all of the Eagle's systems (the F-15 was the world's first all-digital production airplane).

Superior pilot training made the F-15 the safest fighter aircraft in air force history, and it was the only fighter in history to complete its first five thousand flight hours without an accident. Before being assigned to an operational tactical fighter squadron, an F-15 pilot typically would have completed 180 hours of flight time in the Undergraduate Pilot Training Course, and then 35 hours in the T-38 and 60 hours in the F-15 at the Lead-In Fighter Training Program. Thus, the "new" F-15 pilot would have had between 200 and 300 hours of flight time before he was declared qualified for squadron service.

The F-15 also used a "fly-by-wire" control system that greatly reduced the possibility that a pilot might encounter adverse-yaw-induced departure. All air-superiority fighter aircraft built prior to the 1970s used hydraulically boosted mechanical linkages to transmit the pilot's control inputs to the flight-control surfaces. This meant that the airplane had to be designed for static stability in order for a pilot to be able to fly it.[11] Maneuverability, however, decreases as stability increases, but a pilot cannot react quickly enough to control an unstable airplane. Fly-by-wire technology solved this problem.

In a fly-by-wire system, the pilot's control inputs are converted into electrical impulses that are sent to a central computer. At the same time, a system of rate gyros, accelerometers, and air-data probes also feed flight information to the computer. The central computer reads what the pilot wants to do, compares it to what the airplane is actually doing, and then automatically selects the correct control response and deflects the proper control surfaces. Since the computer is actually controlling the airplane, modern fighters are designed for instability in order to have better maneuverability. The computer is also programmed to automatically use the rudder(s) instead of ailerons for roll control in high angle of attack situations, so adverse-yaw departure is much less likely to occur.

During the later phases of its flight test program, the Eagle was successfully flown at a 110-degree angle of attack—20 degrees past vertical. The F-15 also flew at fifteen knots airspeed while in a 67-degree angle of attack. Regarding this ability to fly at extremely high angles of attack, air force test pilot Capt. Michael Sexton remarked: "There's an *immense* difference [between the F-4 and the F-15]. The pilot's relieved of all that tension or apprehension about losing the airplane. So you can concentrate on nailing your target. You just feel comfortable and safe doing whatever you have to do to fight the [other] airplane."[12]

The McDonnell Douglas F-15 Eagle was a vastly better airplane than its older sibling, the F-4 Phantom II, in many other ways. Table 8 illustrates a few of the many differences between the two aircraft. Eagle pilots also benefited from advances in computer technology. The Head-Up Display (HUD) projected the aircraft's airspeed, course heading, altitude, and vital weapons system information onto a transparent screen directly in front of the pilot. A pilot thus could constantly maintain his situational awareness instead of gazing downward to scan the instrument panel. When a potential target was acquired by the F-15's powerful Hughes APG-63 multimode pulse-Doppler radar, the HUD displayed the maximum and minimum firing ranges for the selected weapons systems, how many missiles were available, as well as target altitude, airspeed, closure rate, and aspect angle. Once the enemy aircraft was within effective missile range, the HUD flashed the message "IN RNG" to tell the pilot when to launch the air-to-air missile.

The switch problem so common to Vietnam-era aircraft was practically eliminated with the "hands on throttle and stick" (Hotas) concept. In the Eagle, virtually all of the weapons-system selector switches and firing controls were carefully arranged on the throttle and control stick so that the pilot never had to remove his hands from

Table 8.
F-4E versus F-15 System and Miscellaneous Comparisons

	F-4E	F-15
Cockpit instruments	48	30
Lubrication points	510	202
Hydraulic filters	21	7
Avionics "black boxes"	294	106
Electrical connectors	905	808
Flight control devices	16	9
Fuel system connections	281	97
Access panels	n/a	300% more
Mean time between failure rate	1.3 flight hours	5.6 flight hours
Major accident rate per 100,000 flight hours	14.5	8
Combat turn-around time	17.4 minutes	12 minutes

Source: Drendel, *Eagle,* 5–6.

either the stick or the throttle. Lastly, the sophisticated pulse-Doppler radar allowed the Eagle pilot to locate low-flying aircraft from great distances. For example, an F-15 pilot at an altitude of fifteen thousand feet could acquire an airplane flying a thousand feet above the ground nearly twenty miles away.[13]

The Eagle soon proved itself in dissimilar air-combat tests. In June, 1975, the F-15 fought against A4s, the F-5E, F-106, T-38, A-37, and an F-4E that was equipped with leading edge slats. Out of 202 air-combat maneuvering engagements, only the F-4E was able to fire its weapons against the Eagle. Furthermore, the F-4E was only able to obtain a firing position twice. At the conclusion of the tests, the Eagle kill ratio was 88:1.[14] The ACM tests reflected what actually happened during Operation Desert Storm when air force F-15Cs downed thirty-one Iraqi fixed-wing aircraft and three helicopters without a single air-to-air loss.[15] As of this writing, the F-15A/C/E models own a combined 95:0 kill ratio in the service of the U.S., Israeli, and Royal Saudi Air Forces.

In the thirty years following the end of World War II, TAC had come full circle. By the beginning of 1945, the USAAF had already grounded the German Luftwaffe and helped the navy and Marine

Corps drive the Japanese air forces from the sky. American fighter pilots flew aircraft designed to achieve air superiority and U.S. pilots received the best training available. The Korean War again demonstrated the importance of lightweight, highly maneuverable fighter aircraft and realistic pilot training in winning control of the air. Unfortunately, the war planners of the 1950s and 1960s forgot the lessons learned in MiG Alley and World War II. The worst-case scenario—nuclear war with the Soviet Union—became the air force's primary mission. Instead of seeing Korea as the first of many communist-led limited wars, strategists viewed it as an aberration.

The extreme emphasis given to a global nuclear war also caused the air force to forget that control of the air was a fundamental requirement for victory. In order to justify its existence in the lean years of the New Look defense policy, TAC became a small-scale SAC. Tactical Air Command concentrated on developing two types of airplanes: tactical nuclear bombers and interceptors. The sun had finally set on the day of the dogfight, or so the planners and strategists thought. As a result, U.S. Air Force pilots were not properly trained in air-to-air combat, and the type of aircraft they flew further limited their performance. Those sophisticated, supersonic interceptors and tactical nuclear bombers struggled for survival against the seemingly obsolete North Vietnamese MiGs.

By 1968, however, TAC realized that it was in serious trouble and began taking corrective action. The Wild Weasels and electronic countermeasure pods helped reduce the surface-to-air missile threat while simultaneously allowing strikes to be flown at altitudes above the range of most antiaircraft artillery and automatic weapons fire. The F-105 hydraulic problem was finally resolved, and the F-4E received a 20-mm internal Gatling gun. After the war, the air force purchased the McDonnell Douglas F-15 Eagle, which not only corrected the flaws of the F-4 Phantom, but also became the first true air-superiority aircraft in the air force inventory since the F-86 Sabre. Most importantly, however, the air force began providing realistic fighter-pilot training with the Lead-In Fighter Training Program, the Aggressor Squadrons, and the Red Flag exercises. Tactical Air Command's critical self-examination in the later stages of the war in Southeast Asia was long and difficult, but its later successes proved that it had been a worthy endeavor. The command-wide reversal in policy from an obsession with tactical nuclear warfare to a balanced tactical air force was not timely, but it was effective.

Notes

Introduction

1. For a detailed account of the shoot down and subsequent rescue of Capt. Roger Locher, see Jeffrey Ethell and Alfred Price, *One Day in a Long War,* 48–64, 147–48, 155–68.

2. Ibid., 160–61. "Guard" was a channel open to all U.S. aircraft.

3. Col. Phillip Handley, USAF (Ret.), provided a transcript and audio recording of the engagement to the author.

4. One USAF F-4E, also from the 432nd TRW, was hit in the left wing by a surface-to-air missile during the rescue mission for Captain Locher. Capts. G. W. Hawks, Jr., and D. B. Dingee flew back to Thailand and ejected, where they were rescued. Both men suffered only minor injuries. No naval or Marine Corps fixed-wing aircraft were lost in the engagement (Center for Naval Analyses Database, Alexandria, Va. [hereafter CNA Database]).

5. Carl Berger et al., eds., *The United States Air Force in Southeast Asia, 1961–1973,* 211.

6. Ibid.

7. Ibid., 212.

8. Ibid., 212–13.

9. Ibid., 213.

10. Ibid., 217.

11. CNA Database. Major Bagley survived the ejection, became a prisoner of war, and returned to the United States in 1973.

12. Berger, et al., eds., *Air Force in Southeast Asia,* 217, 221.

13. Ibid., 219. Berger et al., eds., argue that the Tet Offensive was such a surprise since most reconnaissance assets were allocated to covering the siege at Khe Sanh (ibid., 218).

14. Ibid., 221.

15. Ibid.

16. CNA Database.

17. Berger, et al., eds., *Air Force in Southeast Asia,* 169–70.

18. Michael J. H. Taylor, ed., *Jane's American Fighting Aircraft of the 20th Century,* 158, 201–203. Data is for a C-130H, which did not serve in Vietnam, but this is a reasonable estimate for the earlier models.

19. Berger, et al., eds., *Air Force in Southeast Asia,* 170.

20. Ibid., 170–71.

21. Taylor, *Jane's American Fighting Aircraft,* 130–31.

22. Berger, et al., eds., *Air Force in Southeast Asia,* 171.

23. Ibid., 174.

24. Ibid., 175–76.

25. Ibid., 177–83.

26. Ibid., 185; CNA Database.

27. Jacksel M. Broughton, *Going Downtown: The War against Hanoi and Washington;* John B. Nichols and Barrett Tillman, *On Yankee Station: The Naval Air War in Vietnam,* 15–32; Joe Patrick, "Testing the Rules of Engagement," *Vietnam,* Dec., 1997, 46–52, 60–61.

28. H. R. McMaster, *Dereliction of Duty: Lyndon Johnson, Robert McNamara, the Joint Chiefs of Staff, and the Lies That Led to Vietnam,* 21.

29. Ibid., 61.

30. Broughton, *Going Downtown,* 90.

31. *Air War Symposium, 22nd National Convention—Air Force Association* (Maxwell AFB, Ala.: U.S. Air Force Oral History Interview no. 96, Project Corona Harvest no. 0010108, Apr. 4, 1968), 19; Air Force Historical Research Agency (hereafter AFHRA), K239.0512–096 (Transcript from a tape recording).

32. Broughton, *Going Downtown,* 91.

33. Mark Jacobsen, "Washington's Management of the Rolling Thunder Campaign," in *Command and Control of Air Operations in the Vietnam War: Colloquium on Contemporary History in Washington, D.C., January 23, 1991,* 17–18; Col. Jacksel M. Broughton to author, Oct. 30, 1999.

34. Broughton to author, Oct. 30, 1999. Emphasis in original.

35. Gordon Nelson, ed., *The Battle for the Skies over North Vietnam,* 252.

36. Graham Cosmas, "General Westmoreland and Control of the Air War," in *Command and Control of Air Operations,* 30.

Chapter 1. Politics and Perceptions

1. For those who desire a survey of the U.S. military between World War II and the Vietnam War, see Allan R. Millett and Peter Maslowski, *For the Common Defense: A Military History of the United States of America,* 471–541.

2. Wesley Frank Craven and James Lea Cate, eds., *The Army Air Forces in World War II,* vol. 3, *Europe: Argument to V-E Day, January 1944 to May 1945,* 8. Emphasis in General Arnold's original message.

3. *The United States Strategic Bombing Survey, Summary Report (European War),* 38.

4. *The United States Strategic Bombing Survey, Summary Report (Pacific War),* 108.

5. Robert Frank Futrell, *Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force, 1907–1960,* vol. 1, 173, citing a memorandum by Col. Philip D. Cole to Col. Reuben C. Moffat on "A Realistic Conception of a Post-War Air Force," Aug. 22, 1945.

6. Ibid., 285.

7. Caroline F. Ziemke, "In the Shadow of the Giant: USAF Tactical Air Command in the Era of Strategic Bombing, 1945–1955" (Ph.D. diss., Ohio State University, 1989), 51.

8. Ibid., 66–67.

9. Katherine Johnsen, "Air Force–Army Fight?" *Aviation Week,* Aug. 13, 1951, 12.

10. "Budget Surprise," *Aviation Week,* May 18, 1953, 12.

11. Katherine Johnsen, "House Group Approves Airpower Plan," *Aviation Week,* May 14, 1956, 27.

12. Hanson W. Baldwin, "New Steps for Defense," *New York Times,* Nov. 25, 1948, 4.
13. Ziemke, "Shadow of the Giant," 102–103.
14. Johnsen, "Air Force–Army Fight?" 12.
15. Ernest K. Lindley, "Notes on the Military Budget," *Newsweek,* Oct. 1, 1951, 24.
16. Ziemke, "Shadow of the Giant," 240.
17. Walter J. Boyne, *Beyond the Wild Blue: A History of the United States Air Force, 1947–1997,* 58–59.
18. William M. Reid, "Tactical Air in a Limited War," *Air University Quarterly Review* 8, no. 2 (spring, 1956): 40.
19. Carl Spaatz, "Learning the Lessons of Korea," *Newsweek,* Oct. 16, 1950, 23.
20. James Ferguson, "The Role of Tactical Air Forces," *Air University Quarterly Review* 7, no. 2 (summer, 1954): 30.
21. Hanson W. Baldwin, "The Bomb and a Battle," *New York Times,* Apr. 1, 1954, 21.
22. Boyne, *Beyond the Wild Blue,* 63.
23. "Air Program Takes Lead," *Business Week,* Jan. 30, 1954, 26.
24. Ziemke, "Shadow of the Giant," 240.
25. Ibid., 241–42.
26. Theodore H. White, "Revolution in the Pentagon," *Look,* Apr. 23, 1963, 46.
27. *The Budget of the United States Government for the Fiscal Year Ending June 30, 1961.* The data for tables 1 through 4 were compiled from reviewing the "Total Obligational Authority" in the Department of Defense section and the "Aircraft and Related Procurement" and "Aircraft and Related Procurement-Liquidation of Contract Authorization" in both the Department of the Navy and the Department of the Air Force sections of the federal budget for the years 1949 to 1961.
28. Congress, House, Committee on Appropriations, Subcommittee of the Department of Defense Appropriations, *Department of Defense Appropriations for 1960, Part 2: Financial Statements of Field Commanders,* 86th Cong., 1st sess., 1959, 424.
29. Claude Witze, "TAC Is Vital to Our Deterrent Power," *Air Force Magazine,* May 1959, 45.
30. Ziemke, "Shadow of the Giant," 302–303.

Chapter 2. Higher, Faster, Mediocre

1. Harold Fischer, "Kismet and the Paper Tiger," in Joe Foss, Matthew Brennan et al., *Top Guns,* ed. Paul McCarthy, 321. The air force selected the Republic F-84 primarily because it was the only readily available, jet-powered tactical aircraft capable of carrying the Mark VII atomic bomb.
2. John D. Anderson, Jr., *Introduction to Flight,* 184.
3. Ibid., 329.
4. Ibid., 331.
5. *Mission Employment Tactics/Fighter Fundamentals,* vol. 7, *F4,* 4–26.
6. Anderson, *Introduction to Flight,* 329.
7. Ibid., 331.
8. Pete Bonanni, *Art of the Kill: A Comprehensive Guide to Modern Air Combat,* 39.
9. Anderson, *Introduction to Flight,* 335.
10. Ibid., 336.
11. Bryce Walker, *The Epic of Flight: Fighting Jets,* 18–20.
12. Ibid., 32.

13. Taylor, *Jane's American Fighting Aircraft,* 259; Robert Jackson, *F-86 Sabre: The Operational Record,* 4–6.

14. Robert McLarren, "Design Highlights of North American F-86," *Aviation Week,* Nov. 21, 1949, 22.

15. Ray Rice, "Evolution of the F-86 Sabre Jet Fighter," *Automotive Industries,* Apr. 15, 1953, 48, 100.

16. Jack Cox, "Reminiscing with Bob Hoover, Part 2," *Sport Aviation,* Aug., 1983, 47. Bob Hoover was a career test pilot for North American Aviation (NAA).

17. North American Aviation also developed an all-weather, radar-guided interceptor version of the Sabre, which was designated the F-86D. Subsequent models were known as the F-86K and F-86L Sabre. See Taylor, *Jane's American Fighting Aircraft,* 257–58.

18. Bob Hoover wrote: "We found that maintenance on the slat rollers had not been up to par and had been causing the sort of condition that I got into [a flat spin]. . . . The result was a redesign of the slats—with side rollers so they could not bind up" (Cox, "Reminiscing with Bob Hoover," 47).

19. Jackson, *F-86 Sabre,* 36–37.

20. Ibid., 38.

21. William J. Coughlin, "F-86 'Gimmick': Improved Wing," *Aviation Week,* Sept. 7, 1953, 15.

22. Donald K. Evans, "My Love Affair with the Sabre," *Air Force Magazine,* Oct., 1978, 81, 83.

23. Enzo Angelucci and Peter M. Bowers, *The American Fighter,* 343.

24. William Wescott, "Gunnery," in Foss, Brennan et al., *Top Guns,* 390.

25. *Jane's All the World's Aircraft, 1956–1957,* 201.

26. "The Soviet's MiG-15," *General Intelligence Selected Topics,* Deputy Chief of Staff, Intelligence, Fifth Air Force, 14 Nov. 1955, 2–5; Hans-Heiri Stapfer, *MiG-15 in Action,* 7–8; Yefim Gordon and Vladimir Rigmant, *MiG-15: Design, Development, and Korean War Combat History,* 140–43.

27. Chuck Yeager and Leo Janos, *Yeager: An Autobiography,* 205, 206. Defecting North Korean pilot No Kim-Sok (or Ro Kum Suk) flew the MiG-15bis to Kimpo Air Base. The defecting pilot received the promised $50,000 bounty for the MiG plus a $50,000 bonus. In 1957, the U.S. government offered to return the aircraft to its "rightful owners," but the offer was ignored. The aircraft is currently displayed at the USAF Museum at Wright-Patterson AFB, Ohio.

28. An easy-to-understand explanation of common MiG tactics in Korea can be found in "MiG Maneuvers," *Air University Quarterly Review* 6 (winter, 1953–54): 8–13.

29. Taylor, *Jane's American Fighting Aircraft,* 258; Jackson, *F-86 Sabre,* 112–15.

30. Lou Drendel, *USAF Phantoms in Combat,* 5.

31. Ibid., 6–7.

32. *Jane's All the World's Aircraft,* 201; Hans-Heiri Stapfer, *MiG-17 Fresco In Action,* 4–5.

33. Stapfer, *MiG-17 Fresco In Action,* 8.

34. Nichols, *On Yankee Station,* 168.

35. William J. Coughlin, "F-100 Passes Mach 1 in Transonic Dives," *Aviation Week,* Oct. 26, 1953, 12.

36. Taylor, *Jane's American Fighting Aircraft,* 260–61; Angelucci and Bowers, *American Fighter,* 354–55.

37. The YF-100A exceeded Mach 1.0 on its first flight, which occurred on May 25,

1953. The SM-9/1 (MiG-19) did not break the sound barrier until after January 5, 1954, and the XF8U-1 (F8A) Crusader did not fly until March 23, 1955.

38. "Super-Sabre Details: More Thoughts on the North American F-100A," *Flight,* July 30, 1954, 137.

39. Six accidents with both the YF-100 prototypes and the first production F-100As, including one that killed NAA test pilot George Welch, revealed that the size of the vertical tail needed to be increased by 27 percent. North American Aviation invested a substantial sum of money and took several months to analyze the accidents. To its credit, NAA freely distributed its findings on supersonic control surfaces to all U.S. aerospace companies in hopes of preventing further loss of life.

40. "Supersonic Fighter: A Critical Examination of the F-100A Super Sabre," *Flight,* May 20, 1955, 680–81.

41. "The Big Noise: F-100Cs in Service with the U.S.A.F. in Germany," *Flight,* June 8, 1956, 696.

42. Ibid.

43. Ibid., 697.

44. David A. Anderton, *North American F-100 Super Sabre* (London: Osprey Publishing Ltd., 1987), 46; Taylor, *Jane's American Fighting Aircraft,* 260.

45. Bert Kinzey, *F-100 Super Sabre,* 8.

46. Department of the Air Force, Headquarters, United States Air Force, Directorate of Requirements, "Proposed Program for Lightweight Day Fighters," in *History of the Tactical Air Command,* vol. 5, 1 July–31 Dec. 1952, Supporting Document no. 1, 1.

47. *Jane's All the World's Aircraft,* 200–201; Hans-Heiri Stapfer, *MiG-19 Farmer in Action,* 7–9.

Chapter 3. Unprepared by Design

1. Air density affects available thrust. As altitude increases, air density and the amount of thrust available decreases. For example, between sea level and thirty thousand feet on a standard day, the available engine thrust decreases by a factor of approximately 2.65. Unfortunately, the weight of the aircraft remains relatively constant (its weight can only decrease by burning fuel and releasing ordnance). Thus, sustained vertical flight is often possible only at lower altitudes.

2. Cunningham and Ethell, *Fox Two,* 107.

3. Drendel, *USAF Phantoms in Combat,* 5–6.

4. For a detailed analysis of American MiG kills in Southeast Asia see Lou Drendel, *And Kill MIGS: Air to Air Combat in the Vietnam War,* and James N. Eastman, Jr., Walter Hank, and Lawrence J. Paszek, eds., *Aces and Aerial Victories: The United States Air Force in Southeast Asia, 1965–1973.*

5. Bonanni, *Art of the Kill,* 93.

6. Crusader pilots achieved the highest MiG kill ratio of the war. Navy F8 pilots scored nineteen confirmed MiG kills at a loss of three aircraft, or a 6.33:1 kill ratio. By comparison, air force F-4s earned a 3.07:1 kill ratio (107.5 MiGs–35 F-4s), and navy F4s earned a slightly better 5.42:1 kill ratio (38 MiGs–7 F4s). See Nichols, *On Yankee Station,* 168.

7. F-100s flew 344,619 combat and combat-support sorties in Southeast Asia from April, 1965 to March, 1973 (CNA Database). The single-seat F-100D was used primarily in South Vietnam for close air support. The two-seat F-100Fs were used mostly in North

Vietnam as either Wild Weasels (suppression of enemy air defenses) or as fast forward air controllers (Fast FACs) under the "Misty" program. The Super Sabre was never employed as an air superiority aircraft in the Vietnam War.

8. Angelucci, *American Fighter,* 282–87; Taylor, *Jane's American Fighting Aircraft,* 212–13.

9. The rules of engagement for most of the war prohibited the bombing of North Vietnamese airfields, and the MiG threat grew steadily until drastic action was deemed necessary. Before Operation Bolo, MiG pilots often attacked a strike force as it was approaching a target, forcing the bomb-laden aircraft to jettison their ordnance prematurely. Instead of dueling with the strike aircraft, however, the MiGs would flee the area and retreat to the safety of their home airfields. The first Operation Bolo mission occurred on January 2, 1967. Fourteen flights of Air Force F-4s from the 355th, 388th, 8th, and 366th Tactical Fighter Wings expertly imitated an inbound F-105 strike force. Four flights of F-104s simulated F-4 Phantom fighter escorts for the bogus strike force. Falling for the ruse, the MiGs pilots scrambled to intercept the "bombers." In the ensuing air battle led by Col. Robin Olds, the Phantoms shot down seven MiG-21s without the loss of a single aircraft. See Capt. Leroy W. Thornal, interview by Maj. Harry Shallcross, Sept. 13, 1967, interview K239.0512–012, transcript, AFHRA, 10–11; Drew Middleton, et al., *Air War—Vietnam,* 241–47; and Charles A. Ravenstein, "Operation Bolo," in "10 Great Planes and Pilots," *Air Classics* special issue, summer, 1986, 66–72.

10. Angelucci and Bowers, *American Fighter,* 99–102; Taylor, *Jane's American Fighter Aircraft,* 92–93.

11. Robert F. Dorr and Chris Bishop, eds., *Vietnam Air War Debrief,* 23; CNA Database.

12. Kenneth R. Lundquist, "Pilot's Report," in Bert Kinzey, *F-102 Delta Dagger,* 32.

13. F-105 Wild Weasel aircraft continued flying combat missions until April 27, 1973.

14. Republic Aircraft produced a total of 833 F-105s. Between its first flight on October 22, 1955, and its first combat mission on August 14, 1964, 94 of those 833 aircraft were lost in accidents, which makes 739 Thunderchiefs in service at the beginning of the air war. Twenty-eight of the 94 accidents involved the older A and B models, and the surviving 52 A and B variants were never sent to Southeast Asia. Thus, only 687 F-105s were combat-ready in 1964. During the war, 62 Thunderchiefs were lost to in-flight operational accidents and 334 F-105s were lost in aerial combat for a total of 396 aircraft destroyed. Dividing 396 lost aircraft by the 687 available for combat and multiplying the result by 100 percent reveals that 57.64% of all available, combat-ready F-105s were lost in the Vietnam War (Howard Plunkett, research notes for "F-105 Operational History," Manuscript [photocopy in author's collection]; Howard Plunkett to author, July 2, 1998; CNA Database).

15. William S. Reed, "TAC Trains Pilots for F-105D Missions," *Aviation Week and Space Technology,* Apr. 17, 1961, 89.

16. Jack Dean, "F-105: All-Out Warrior in a Limited War," *Wings,* Apr., 1991, 19, 23.

17. *History of the 388th Tactical Fighter Wing,* vol. 3, *July–September 1970,* Supporting Document no. 1, 2.

18. Scott Duncan, "The Combat History of the F-105," *Aerospace Historian* 22, no. 3 (Sept., 1975): 122.

19. Taylor, *Jane's American Fighter Aircraft,* 278–79; Angelucci and Bowers, *American Fighter,* 407–10. Bert Kinzey, *F-105 Thunderchief,* 29.

20. Eastman, *Aces and Aerial Victories,* 10. The remainder of the quote is worth citing—but only for political reasons: "As a solution [to the MiG problem], the Joint Chiefs

of Staff had recommended that North Vietnamese airfields be struck to reduce the MIG threat. But Secretary [of Defense Robert] McNamara believed that the enemy threat was not sufficient to interfere with strike operations." More than half of the strike aircraft were forced to prematurely jettison their ordnance when attacked by MiGs, yet the MiGs were an insufficient threat?

21. Taylor, *Jane's American Fighting Aircraft,* 241–43, 278–79; Angelucci and Bowers, *American Fighter,* 310–17, 407–10.

22. Al Santoli, *Leading the Way: How Vietnam Veterans Rebuilt the U.S. Military—An Oral History,* 46.

23. Hans Halberstadt, *The Wild Weasels: History of US Air Force SAM Killers, 1965 to Today,* 62.

24. Cecil Brownlow, "F-105 Modified for Vietnam Role," *Aviation Week and Space Technology,* May 22, 1967, 17.

25. Don Carson, "Flying the Thud," *Air Force Magazine,* Apr., 1974, 18.

26. Ibid., 23

27. Nichols, *On Yankee Station,* 167–69

28. Jack Broughton, *Thud Ridge,* 37. Colonel Broughton and two of his pilots were court-martialed and charged with four counts of conspiracy against the U.S. government, after the two pilots were accused of violating the rules of engagement. The two pilots were flying in the area of Cam Pha Harbor when ground guns protecting the harbor opened fire on them. One of the pilots returned fire on the guns and later reported to Colonel Broughton that at the last instant he had seen a surface ship near the guns, and did not know if any of his cannon rounds had struck the ship. The colonel ordered his men to remain silent and then destroyed the unprocessed gun camera film from the two aircraft.

The Soviets filed a formal complaint, accusing the Americans of an unprovoked attack on a Soviet vessel. In the ensuing trial, the colonel assumed full responsibility for the actions of his pilots, and the two pilots were acquitted. The court convicted Colonel Broughton of destroying $43.60 worth of government property (the cost of the gun-camera film), and of processing gun-camera film in a nonstandard manner. His sentence included a $600 fine and a letter of admonishment. Colonel Broughton appealed the conviction, which was later overturned. The incident, however, effectively precluded him from further air force command or advancement, and he retired from the military (Broughton, *Going Downtown,* 193–273; Broughton to author, Oct. 30, 1999).

29. Broughton, *Thud Ridge,* 70.

30. Ibid., 148–49.

31. J. S. Butz, Jr., "F-105s in Vietnam: New Luster for a Tarnished Image," *Air Force Magazine,* Oct., 1966, 39.

32. Mark Clodfelter, *The Limits of Air Power: The American Bombing of North Vietnam,* 31.

33. Butz, "F-105s in Vietnam," 38.

34. Broughton, *Going Downtown,* 143.

35. Nichols, *On Yankee Station,* 76–77.

36. Broughton, *Thud Ridge,* 37.

37. Brownlow, "F-105 Modified for Vietnam Role," 17; Cecil Brownlow, "USAF to Strengthen F-105 Survivability," *Aviation Week and Space Technology,* Sept. 23, 1968, 81.

38. Broughton, *Thud Ridge,* 37.

39. "Thunderchief," *Air University Review* 34 (Feb., 1983): 53 n.

40. Cecil Brownlow, "Pause Cuts Soaring Loss Rates," *Aviation Week and Space Technology,* July 15, 1968, 14.

41. Ibid; CNA Database.

42. Brownlow, "Pause Cuts Soaring Loss Rates," 16.

43. Robert K. Wilcox, *Scream of Eagles,* 25.

44. Anthony M. Thornborough, *USAF Phantoms: Tactics, Training, and Weapons,* 11.

45. John Trotti, *Phantom over Vietnam,* 37.

46. The 432nd Tactical Reconnaissance Wing mounted inexpensive automobile rearview mirrors inside the pilot's canopy. A McDonnell Aircraft field representative noticed it and proposed that all Phantoms be modified in a similar fashion. After hundreds of hours of research and testing, McDonnell engineers designed an external rearview mirror that protruded from the top of the pilot's and weapons systems officer's canopies. The new mirror cost several hundred dollars, increased drag, and created a deafening noise at airspeeds above 450 knots.

47. Phil Handley, "Down to the Last Drop," *The Fighter Pilot Chronicles,* Oct., 1993, 2 n 2.

48. Ibid.

49. Handley, "Down to the Last Drop," 2. A common misconception is that gravity simply pulls external fuel tanks or ordnance away from an airplane in a classic ballistic arc. Unfortunately, a 450-knot airspeed, the release angle, and the shape of the tank or ordnance all combine to create a lifting force that is difficult to predict.

50. Brig. Gen. Robin Olds, interview by Majors Geffen and Folkman, date unknown, interview K239.0512–051, transcript, AFHRA, 75–76 (hereafter Olds interview).

51. *Project Red Baron III: Air to Air Encounters in Southeast Asia,* vol. 1, *Executive Summary,* 23. Col. Phil Handley writes, "Through trial and error, we found that if it [the centerline fuel tank] was jettisoned during a steady 4G pull-up from level-flight (with the ball centered), it always came off cleanly" (Handley, "Down to the Last Drop," 2).

52. *Project Red Baron III,* 27.

53. Ibid., 27–28.

54. Some MiG-17s were later modified to carry two AA-2 Atoll heat-seeking missiles in addition to their internal cannons.

55. *Jane's All The World's Aircraft,* 200–201; John W. Taylor, ed., *Jane's All the World's Aircraft, 1968–1969,* 415–16.

56. Stapfer, *MiG-17 Fresco in Action,* 23–24. See also Don Linn and Don Spering, *MiG-21 Fishbed in Action,* 21. The names "Fresco," "Farmer," and "Fishbed" are the NATO code names for the respective MiG aircraft. In order to reduce radio confusion, the NATO Air Standards Coordinating Committee named Warsaw Pact aircraft as follows: fighter aircraft names must be distinct and begin with the letter "F," propeller-driven fighters were assigned one syllable names, and jet-powered fighters had two syllable names.

57. Olds interview, 70–72.

58. *Project Red Baron III,* 14–21, 29–33.

59. Ibid.

60. William V. Kennedy, "The Case for a New Fighter-Interceptor," *Flying,* Jan., 1962, 38.

61. Frederick C. Blesse, *Check Six: A Fighter Pilot Looks Back,* 148.

62. Olds interview, 76.

63. William W. Momyer, *Air Power in Three Wars,* 157.

64. Cunningham and Ethell, *Fox Two,* 136.

65. Olds interview, 69.

66. Ibid., 70.

67. Nichols, *On Yankee Station,* 76–77.

68. Olds interview, 68–69.

69. Blesse, *Check Six,* 150.

70. Ibid., 151.

71. Ibid., 153.

72. Thornborough, *USAF Phantoms,* 15–16; Taylor, *Jane's American Fighting Aircraft,* 242.

73. Thornborough, *USAF Phantoms,* 17.

74. Earl H. Tilford, Jr., *Crosswinds: The Air Force's Setup in Vietnam,* 34.

75. James Fallows, *National Defense,* 45. Remember that the cornering airspeed for the F-4 Phantom is 450 knots calibrated air speed.

Chapter 4. "We're a Little Lacking There"

1. Capt. Leroy W. Thornal, interview by Maj. Harry Shallcross, Sept. 13, 1967, interview K239.0512—012, transcript, AFHRA, 12–13 (hereafter Thornall interview).

2. Kenneth P. Werrell, *Archie, Flak, AAA, and SAM: A Short Operational History of Ground-Based Air Defenses,* 103–104.

3. Optical tracking devices were installed in the nose cone of the SA-2 in October, 1967, thus limiting the time that the Fan Song radar had to actively guide the missile to its target. See Middleton, *Air War—Vietnam,* 247. For more information on Vietnam-era SAM countermeasures, see Harold Johnson, *F-105 Combat Tactics and Techniques,* chaps. 5 and 6.

4. Ben R. Rich and Leo Janos, *Skunk Works: A Personal Memoir of My Years at Lockheed,* 160; Stapfer, *MiG-19 Farmer In Action,* 32, 34.

5. David A. Anderton, *The History of the U.S. Air Force,* 153.

6. Peter B. Mersky, and Norman Polmar, *The Naval Air War in Vietnam,* 27–28.

7. Larry Davis, *Wild Weasel: The SAM Suppression Story,* 8.

8. John Morrocco et al., *The Vietnam Experience—Thunder from Above: Air War, 1941–1968,* 106–107.

9. Mersky, *Naval Air War in Vietnam,* 35.

10. Davis, *Wild Weasel,* 8.

11. Zalin Grant, *Over the Beach: The Air War in Vietnam,* 59.

12. Nichols, *On Yankee Station,* 50–51.

13. Ibid., 49.

14. Jeffrey L. Levinson, *Alpha Strike Vietnam: The Navy's Air War, 1964–1973,* 21.

15. The ALE-40 is a chaff and flare dispenser mounted in an external pod. During Operation Linebacker II, the air force mounted special chaff dispensers on F-4s, and those aircraft were used exclusively as "chaff bombers." Their purpose was to create an "aluminum corridor" for the B-52 bombers and other strike aircraft to fly through. Individual fighter aircraft, however, did not normally carry a chaff dispenser until the arrival of the ALE-40. Flares serve as decoys for heat-seeking missiles because they burn several hundred degrees hotter than an engine in full afterburner mode while also emitting a frequency that is compatible with that of the aircraft's exhaust heat signature (Anderton, *History of the U.S. Air Force,* 206).

16. Davis, *Wild Weasel,* 4.

17. Ibid., 5.

18. Ibid.

19. Ibid., 6.

20. Ibid.

21. Tilford, *Crosswinds,* 25.

22. *Report by Air Staff Task Force on Surface To Air Missiles in SEA,* Attachment 1, "Charter, Air Staff Task Force on SAM Missiles," 1. Only Attachment 1 has been declassified.

23. Ibid.

24. Ibid., 2.

25. Davis, *Wild Weasel,* 8.

26. Halberstadt, *Wild Weasel,* 13.

27. Davis, *Wild Weasel,* 10.

28. Harold E. Johnson, "Of Bears, Weasels, Ferrets and Eagles," *Air University Review* 33, no. 2 (Jan.-Feb., 1982): 87–88.

29. Davis, *Wild Weasel,* 11.

30. Ibid. When discussing Wild Weasel crews, the pilot's name will be listed first and the electronic warfare officer's name second.

31. Ibid., 11–12.

32. Ibid., 12.

33. Ibid., 13. See also Halberstadt, *Wild Weasel,* 15, 59.

34. Davis, *Wild Weasel,* 11.

35. Halberstadt, *Wild Weasel,* 59.

36. Broughton, *Going Downtown,* 163.

37. Davis, *Wild Weasel,* 13.

38. Halberstadt, *Wild Weasel,* 60–61.

39. Davis, *Wild Weasel,* 14.

40. Ibid.

41. Davis, *Wild Weasel,* 16. The twenty-five Wild Weasel crews and eleven aircraft represent only the air force's contribution. The navy modified carrier-based A6B Intruders with equipment identical to the air force F-105F. Unlike the air force, however, navy A6B crews received no special training in locating and destroying SAM sites. Naval strategy called for an A6B to locate the Fan Song radar and then for two A6A Intruders to destroy the site (ibid., 26–27).

42. Ibid., 17.

43. Ibid.

44. Johnson, "Of Bears, Weasels, Ferrets, and Eagles," 89.

45. Davis, *Wild Weasel,* 18–19.

46. Ibid., 17.

47. Broughton to author, Oct. 30, 1999.

48. Davis, *Wild Weasel,* 14.

49. Ibid., 41.

50. Ibid., 31.

51. Ibid., 44.

52. Ibid., 30.

53. Ibid.,50–51.

54. John B. Morrocco et al., *The Vietnam Experience—Rain of Fire: Air War, 1969–1973,* 157.

55. Martin F. Herz, *The Prestige Press and the Christmas Bombing, 1972,* 54.

56. *Project Red Baron III,* 6.

57. Thornborough, *USAF Phantoms,* 55.

58. Davis, *Wild Weasel,* 54–55; Halberstadt, *Wild Weasel,* 70–72.

Chapter 5. An Out-and-Out Crime

1. Thornal interview, 13–14.

2. Cunningham and Ethell, *Fox Two,* 135.

3. Robert L. Shaw, *Fighter Combat: Tactics and Maneuvering;* Mike Spick, *Fighter Pilot Tactics.*

4. Shaw, *Fighter Combat,* 61.

5. "Performance Comparison Between F-86 and MIG-15 Aircraft," *Crew Training Air Force History,* vol. 4., *1 July–31 December 1952,* Supporting Document no. 42, 1.

6. Ibid., "Format for the Syllabus of Instruction, F-86, Day Fighter (Air-to-Air), Course Number 105902," Supporting Document no. 25, 3, 15–22. The extremely high altitudes reflected the aerial combat conditions of the Korean War.

7. Ziemke, "Shadow of the Giant," 268.

8. *Evaluation of Exercise Sage Brush,* comments by Brig. Gen. Bruce K. Holloway, deputy commander of the "Sixth Air Army," in response to a questionnaire by the Ninth Air Force Evaluation Group, chapter 15, question 1, response b.

9. Ibid.

10. Ibid., comments by Brig. Gen. Eugene H. Underhill, commander of the "Sixth Air Army," in response to a questionnaire by the Ninth Air Force Evaluation Group, chapter 15, question 1, response d.

11. "William Tell 1960," *Fighter Weapons Newsletter,* Dec., 1961, 29.

12. George M. Nedel, "Rotational Training," *Fighter Weapons Newsletter,* Mar. 1961, 6.

13. Ibid., 7.

14. *History of the 12th Air Force,* vol. 1, *1 January–30 June 1965,* 99–106.

15. CNA Database; Dorr and Bishop, eds., *Vietnam Air War Debrief,* 23. The MiG-21 loss figures do not include the two aircraft downed by B-52D tail gunners.

16. Gen. Daniel James, interview by Gordon F. Nelson, Mar. 4, 1977, Interview K239.0512–1082, transcript, AFHRA, 15.

17. Thirty-three aircraft were lost during the first few years of Red Flag at Nellis AFB, Nevada. Red Flag is a realistic training exercise that will be discussed later in this chapter.

18. Lt. Col. Doug Campbell, USAF (Ret.), of Lubbock, Texas, interview by author, Mar. 31, 1995, Lubbock, Texas. Lieutenant Colonel Campbell served in numerous operational tours in the U.S. Navy and U.S. Air Force, flying A7Es, A-10As, and F-117As.

19. *Air Force Regulation no. 53–25,* "Schools: USAF Fighter Weapons School (Tactical)," Apr. 7, 1960, 1.

20. *History of the United States Air Force Fighter Weapons School (TAC) and 4525th School Squadron (Tactical Weapons),* vol. 3, *1 January–30 June 1961,* page titled "Academic Section—Problems."

21. Thornal interview, 14.

22. Col. Phil Handley, USAF (Ret.), interview by author, Mar. 23, 1995, Midland, Texas.

23. Broughton to author, Oct. 30, 1999.

24. Nichols, *On Yankee Station,* 74.

25. Lou Drendel, *USMC Phantoms In Combat,* 7.

26. Paul T. Gillcrist, *Crusader! Last of the Gunfighters,* 273–74.

27. Ibid., 242.

28. Ibid., 242; and Barrett Tillman, *MiG Master: The Story of the F-8 Crusader,* 124, 171.

29. Nichols, *On Yankee Station,* appendix C, 168–69.

30. Gillcrist, *Crusader!* 183. Guns were involved in only seven of the Crusader's total of twenty-one confirmed and probable kills. The other fourteen kills were made using only the AIM-9 Sidewinder.

31. Ibid., 228–29.

32. Tillman, *MiG Master,* 118–19.

33. Nichols, *On Yankee Station,* 84.

34. *Project Red Baron III,* 10.

35. Ibid., 12.

36. Ibid., 13.

37. Ibid.

38. Ibid., 28.

39. *History of the Tactical Air Command,* vol. 9, *July 1972–June 1973,* Supporting Document no. 125: William P. McBride, Headquarters, Tactical Air Command, Staff Summary Sheet, Aug. 5, 1972, 1.

40. Ibid.: Donald E. Miller, "Air-to-Air Capabilities Improvement Programs," Headquarters, Tactical Air Command, Staff Summary Sheet, Aug. 4, 1972, 1.

41. Ibid., 2.

42. Ibid.

43. Ibid., Supporting Document no. 144, Attachment 1: "Progress Report of the Air-to-Air Capability Action Group," 1.

44. Ibid., Headquarters, Supporting Document no. 145[1]: Tactical Air Command, Staff Summary Sheet, July 21, 1972, and Supporting Document no. 145[2]: Headquarters, Tactical Air Command, Staff Summary Sheet, Aug. 11, 1972.

45. The air force also formed Aggressor squadrons in England and in the Philippines. Realistic training exercises similar to Red Flag were also held in Europe (Tactical Leadership Program) and in the Pacific (Cope Thunder).

46. Bert Kinzey, *The Fury of Desert Storm: The Air Campaign,* app. 3. Two USAF F-15Es were lost in air-to-ground attacks.

47. Vickie M. Graham, "Ready on the Range," *Airman,* Mar., 1995, 29.

48. W. C. Strand, "Aggressor—The Key to Realistic Air Force Training." (Student thesis, Air Command and Staff School, Air University, Maxwell AFB, Ala., Mar., 1948), 12.

49. Ibid., 27.

50. Lawrence R. Benson, "The New USAF Fighter Lead-In Program: A First Year's Progress Report," *Air University Review* 26 (Mar.-Apr. 1975): 57.

51. *History of the 23rd Tactical Fighter Wing,* vol. 3, *1 July 1967–31 December 1967,* 2–3.

52. John M. Loh, "TAC Safety—Then and Now," *TAC Attack,* May, 1992, 5.

Chapter 6. The Eagle Soars

1. John R. Boyd, interview by Jack Neufeld, May 23, 1973, Interview no. 859, transcript, U.S. Air Force Oral History Program, AFHRA, 32 (hereafter referred to as Boyd interview).

2. Ibid., 16.

3. Steve Pace, "Short Little Ugly F—er—The Magic Wagon," *Airpower* 16, no. 4 (July, 1986): 36.

4. William G. Holder, *A-7 Corsair II,* 57–58. Navy A7A, A7B, and A7E Corsairs flew a combined total of 94,353 combat and combat-support sorties over Southeast Asia, yet only fifty-five Corsairs were lost in combat. Moreover, the A7 achieved the lowest rate of combat losses per one thousand sorties (0.6) of any navy fighter or attack aircraft used in the war (CNA Database).

5. Boyd interview, 28.

6. James Perry Stevenson, *McDonnell Douglas F-15 Eagle,* 12–13. See also Drendel, *Eagle,* 3.

7. Stevenson, *McDonnell Douglas F-15 Eagle,* 15.

8. Taylor, *Jane's American Fighting Aircraft,* 239–40. Angelucci and Bowers, *American Fighter,* 317–20.

9. Drendel, *Eagle,* 9.

10. Unlike its navy counterpart, the F14 Tomcat, the F-15 was never configured to carry the long-range Phoenix air-to-air missile.

11. Static stability is defined as follows: "*If the forces and moments on the body caused by a disturbance tend initially to return the body toward its equilibrium position, the body is statically stable.*" Dynamic stability, which is the time history of the airplane's motion after the initial response to static stability, is defined as follows: *"A body is dynamically stable if, out of its own accord, it eventually returns to and remains at its equilibrium position over time"* John D. Anderson, Jr., *Introduction to Flight,* 362, 364 (Italics in original).

12. Benjamin F. Schemmer, "The Eagle Is Not a Turkey or a Dove," *Armed Forces Journal International* 112, no. 7 (Mar., 1975): 39.

13. Ibid., 43.

14. "F-15 Scores 87% Kills in 202 Air Combat Maneuvering Engagements," *Armed Forces Journal International* 112, no. 11 (July, 1975): 6.

15. Kinzey, *Fury of Desert Storm,* app. 3.

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Index

AA-1 Alkali missile, 58
AA-2 Atoll missile, 40, 47, 57–58, 65
AD-1 Skyraider, 4, 15, 107
adverse yaw departure, 63–64, 95–96, 109–10
aeroelastic divergence, 36, 40
A-4 radar-ranging gun sight, 37
A4 Skyhawk, 70, 107, 111
Aggressor squadrons, 15, 101–102, 104–105, 112
AGM-88 HARM missile, 88
AGM-45 Shrike missile, 81–85, 88
AGM-78 Standard ARM missile, 85, 88
AGM-65 Maverick missile, 86, 88
AIM-4 Falcon missile, 6–7, 58
AIM-9 Sidewinder missile, 33, 58, 60–62, 83, 88, 98–99, 101, 109
AIM-7 Sparrow missile, 6, 52, 58–62, 88, 97–98, 109
Air Combat Command, 104
air combat maneuvering (ACM), 92, 94–95, 97–103, 111
Air Command and Staff College, 22, 103
Air Defense Command, 22, 24, 27, 42, 77, 101
Air Force Association, 17
Air Force Historical Research Agency, 49
Airlift Control Center (ALCC), 11
Air National Guard, 23, 25, 39, 101
Air Research and Development Command, 42
Air Staff Task Force on SAM Missiles, 78
Air-to-Air Capabilities Improvement Program, 15, 100
Air Training Command, 90
Air University, 103
Air War College, 26
ALE-40 chaff and flare dispenser, 74, 87
Alkali missile, 58
ALQ-119 electronic countermeasures pod, 87
ALQ-101 electronic countermeasures pod, 84
ALQ-131 electronic countermeasures pod, 87
ALQ-71 electronic countermeasures pod, 83–84
ALR-31 SEE-SAMS passive warning sensor, 84
Alvarez, Everett J., 71–72
American Volunteer Group (AVG), 91
AN/APQ-120 radar, 62
Anderson, John D., Jr., 31
Anderson, Rudolph, 11, 14, 69
An Loc, South Vietnam, 12
anti-aircraft artillery (AAA), 14–15, 50, 53–54, 70–71, 73, 75, 77–78, 80–81, 86–87, 102, 112
APG-59/AWG-10 radar, 62
APG-63 radar, 110
Apollo space program, 108–109
Applied Technologies, 78, 82
APQ-120 navigation and fire control radar, 87
APR-47 radar homing and warning system, 87–88
APR-38 radar homing and warning system, 87–88
APR-35 panoramic receiver, 84

INDEX

APR-35/36 radar homing and warning system, 84
APR-25 radar homing and warning system, 78, 80, 82, 84
APR-24 radar homing receiver, 76
APR-26 launch warning receiver, 78, 82
area of real-time tracking, 71
Arnold, Henry H., 21
ARN-101 digital navigation and weapons delivery system, 87–88
A7 Corsair II, 15, 107–108
A-7D Corsair II, 15, 107–108
A6 Intruder, 69
ASQ-91 weapons release computer, 88
A-37 Dragonfly, 111
Atoll missile, 40, 47, 57–58, 65
AT-33A Shooting Star, 104
Australia, 12
automatic weapons (AW), 14–15, 53, 70–71, 73, 75, 77–78, 80, 86–87, 102, 112
AZ-EL (azimuth-elevation) system, 82

Bagley, B. R., 10
Baldwin, Hanson W., 24, 26–27
Battle of Britain, 74
Bendix Corporation, 78
B-52 Stratofortress, 18, 24, 27, 78–79, 86
B-47 Stratojet, 27
Bien Hoa Air Base, 11, 18
Bitburg Air Base, 42
Blesse, Frederick C., 8, 59, 61–62, 90
Boeing Aircraft Corporation, 27; and B-17 Flying Fortress, 47, 75; and B-29 Super Fortress, 22, 75–76; and B-47 Stratojet, 27; and B-52 Stratofortress, 18, 24, 27, 78–79, 86; and E-3 Sentry, 102; and KC-135 Stratotanker, 7, 18, 50, 102
Boelcke, Oswald, 90
Bonanni, Pete, 33
Boyd, John R., 90, 106–107
Boyne, Walter J., 26–27
Braven, Richard A., 104
Broughton, Jacksel M., 16–18, 51–53, 83, 96
B-17 Flying Fortress, 47, 75
B-36 Peacemaker, 24, 27
B-25 Mitchell, 75
B-24 Liberator, 75
B-29 Super Fortress, 22, 75–76
B-26 Invader, 9, 76
Bundy, McGeorge, 17
Butz, J. S., Jr., 51–52

Cambodia, 10, 18
Campell, Douglas, 94
Canadian Sabre 5, 42
Canadian Sabre 6, 42
Cannon, John K., 29
Carpet radio transmitter, 74–75
Carrier Task Force 77, 18
Carson, Don, 50
CBU-24/B cluster bomb unit, 83
Cessna: and A-37 Dragonfly, 111; and T-37 Tweet, 103; and T-41 Mescalero, 103
C-47 Skytrain, 11
chaff, 74–76, 86
chaff and flare dispenser, 74, 87
Chain Home radar system, 74
Chennault, Claire, 91
China, 25–26, 90
Christian, George, 17
Christie, Thomas, 106
Christmas bombings, 10, 86–87
Clark Air Base, 18
Clodfelter, Mark, 51
CL-13A Mark 5. *See* Saber 5
CL-13A Mark 6. *See* Sabre 6
cluster bomb unit, 83
Cold War, 102
Cole, Sterling, 24
College Eye airborne control, 56
combat crew training squadrons (CCT), 101, 103–104
Command Operations Center, 11
Common Service Airlift System, 11
C-130 Hercules, 11, 13, 89
C-123 Provider, 11, 13
Consolidated B-24 Liberator, 75
Continental Air Command, 24
Convair: and B-36 Peacemaker, 24, 27; and F-102 Delta Dagger, 23, 27, 46–47, 93; and F-106 Delta Dart, 23, 47, 55, 101, 111
corner velocity, 33, 56
C-7A Caribou, 12–13
Cuban Missile Crisis, 14, 68–69, 76, 81
Cunningham, Randy, 45, 60, 89
CV-2A Caribou, 12

Dallas, Tex., 16
Da Nang Air Base, 89
Davis-Monathan Air Force Base, 93
de Havilland: and C-7A Caribou, 12–13; and CV-2A Caribou, 12; and Mosquito, 34
Dempster Committee, 78–79
Dempster, Kenneth C., 78, 82, 106
Dien Bien Phu, 26
Disco airborne control, 56
dissimilar air combat training (DACT), 90, 101, 104
Disosway, Gabriel P., 106–107
Dixon, Robert J., 101
Domodadovo, Soviet Union, 108
Donovan, John, 80
Doolittle, James H., 21
Douglas: and A4 Skyhawk, 69–70, 107, 111; and AD-1 Skyraider, 4, 15, 107; and B-26 Invader, 9, 76; and C-47 Skytrain, 11; and R-26 Invader, 9; and R-66 Destroyer, 76; and SC-47 Skytrain, 8
Downey, John, 4
Drew Field, 8
Dunn, James, 3

Easter Offensive of 1972, 10, 12
EC-130 Compass Call, 88, 102
EC-121 Warning Star, 46
Eden, Douglas, 5
EF-111A Raven, 75, 88
Eglin Air Force Base, 79
Eighth Air Force, 21
8th Tactical Fighter Wing, 3, 39, 62
834th Air Division, 11
Eisenhower, Dwight D., 13, 27, 29
electronic counter measures, 83–84, 86–87, 112
11th Tactical Reconnaissance Squadron, 9
Ellis, Robert, 4
energy management theory (EMT), 33–34, 90, 106
E-3 Sentry, 102
Evans, Douglas K., 38
Exercise Sage Brush, 76

Fairchild C-123 Provider, 11, 13
Falcon missile, 6–7, 58
Fan Song guidance radar, 68, 78–80, 83–85
Far East Air Forces, 26
F-111A Aardvark, 86
F8 Crusader, 46, 54, 70–71, 97–99
F-84 Thunderjet, 31, 48
F-80 Shooting Star, 31
F-86 Sabre, 31, 36–40, 42, 90–91, 93, 109, 112
Ferguson, James, 26
F-15 Eagle, 15, 44, 102, 108–12
F-51 Mustang, 25
F-5 Freedom Fighter, 90, 101–102, 111
F-4 Phantom II, 3–8, 14–15, 23, 44–46, 49, 52, 54–65, 69–70, 81–82, 85–87, 89–90, 93, 95–98, 100–101, 103–104, 106, 108–12
F-14 Tomcat, 98, 107, 109
F4U Corsair, 25
Fifteenth Air Force, 21
58th Tactical Fighter Squadron, 4
Fighter Mafia, 106–107
Fighter Lead-In Program, 15, 103–104, 109, 112
Fighter Weapons School: and United States Air Force, 87, 92, 94–95, 100–101, 104; and United States Navy, 54, 102
1st Cavalry Division, 12
Fischer, Harold, 31
554th Range Squadron, 102–103
509th Fighter Interceptor Squadron, 47
fly-by-wire control system, 109–10
Flying Tigers, 91
F9F-2 Panther, 72
F-105 Thunderchief, 14–15, 23, 44–54, 57, 64–65, 70, 80, 82–85, 93, 99, 104, 106–107, 112; and Thunderstick 2 modification, 53
F-104 Starfighter, 23, 46–47
F-101 Voodoo, 23, 46–47
F-106 Delta Dart, 23, 47, 55, 101, 111
F-100 Super Sabre, 15, 23, 31, 40–43, 46, 57, 78–79, 80–82, 91, 97, 107
F-100 turbojet engine, 108
F-102 Delta Dagger, 23, 27, 46–47, 93
Ford Aerospace AIM-9B Sidewinder, 33, 58, 60–62, 83, 88, 98–99, 101
483rd Tactical Airlift Wing, 12

414th Combat Training Squadron, 102
460th Tactical Reconnaissance Wing, 9–10
465th Tactical Fighter Training Squadron, 104
432nd Tactical Reconnaissance Wing, 4, 9
France, 26
Freya radar, 74–75
F6 Hellcat, 98
F-16 Falcon, 44, 102
Fuller, David, 97

GBU-15 electro-optical homing glide bomb, 86
General Dynamics: and AGM-78 Standard ARM missile, 85, 88; and EF-111A Raven, 75, 88; and F-16 Falcon, 44, 102; and F-111A Aadvark, 86
General Electric Corporation: and J-35 turbojet engine, 35; and J-47 turbojet engine, 36–37, 39; and J-73 turbojet engine, 39; and J-79 turbojet engine, 44, 49, 55–56, 88; and M61A1 Vulcan cannon, 7, 49, 61–62, 109; and SUU-16 Vulcan cannon, 61–62
George Air Force Base, 67, 89, 104
Germany, 35, 38, 68; and Air Service, 90; and early warning radar, 74–75; and Luftwaffe, 19, 21, 34, 74, 111
Gia Lam Airport, 4
Gillcrist, Paul, 98–99
Gloster Meteor, 42
Great Britain, 35; and atomic parity with U.S., 22; and radar, 74–75; and Royal Air Force, 34, 42, 74
Greece, 27
Green, Stanley, 5, 7
ground control intercept radar, 78, 101
Grumman: and A6 Intruder, 69; and F6 Hellcat, 98; and F9F-2 Panther, 72; and F-14 Tomcat, 98, 107, 109
Guam, 18
Guideline surface-to-air-missile, 4–5, 14, 50, 53–54, 68–70, 76–84, 86–87
Gulf of Tonkin, 4–5, 7, 50
Gulf of Tonkin Incident, 69, 71

Haiphong, North Vietnam, 4, 53, 86–87
Handley, Phillip, 4–8, 56, 63, 95–96
hands-on throttle and stick (HOTAS), 110–11
Hanoi Hilton, 72
Hanoi, North Vietnam, 4, 14, 50, 53, 62, 67–69, 78, 83, 86–87
Hao Lo prison, 72
HARM missile, 88
Hawker Hunter, 42
heads-up display (HUD), 110
Helms, Richard, 17
HH-53 Super Jolly Green Giant, 4
Hillaker, Harold, 106
Hiroshima, Japan, 22
Hitler, Adolf, 34
Ho Chi Minh Trail, 9
Holloman Air Force Base, 104
Holloway, Bruce K., 91–92
Hoover, Robert A., 37
Horner, Charles A., 49–50
House Appropriations Committee, 24
House Armed Services Committee, 24–25
Hughes Aircraft: and APG-63 radar, 110; and AGM-65 Maverick missile, 86, 88; and AGM-88A HARM missile, 88; and AIM-4 Falcon missile, 6–7, 58

IL-28 Beagle, 47
Ilyshin IL-28 Beagle, 47
Indochina, 26
Iraq, 102, 111
IR-133 panoramic receiver unit, 78, 82
Iron Hand, 69–70, 87
Israel, 27; and Israeli Air Force, 111

James, Daniel, 93–94
Japan, 19, 22, 76, 112; and atomic warfare, 22; and early warning radar, 75
J-57 turbojet engine, 42, 97
J-47 turbojet engine, 36–37, 39
Johnson, Harold E., 83
Johnson, Lyndon B., 10, 16–17
Joint Chiefs of Staff (JCS), 16–17, 25
Joint Movements Transportation Board, 11
J-75 turbojet engine, 44, 49
J-79 turbojet engine, 44, 49, 55–56, 88
J-73 turbojet engine, 39
J-35 turbojet engine, 35

Kartveli, Alexander, 48
KC-135 Stratotanker, 7, 18, 50, 102
KC-10A Extender, 102
Kennedy, John F., 16
Kennedy, William, 59
Kep Airport, 4, 69
Khe Sanh, South Vietnam, 10, 12
Kim-Sok, Ho, 39
Kincaid, Thomas, 24
Kinzey, Burt, 42
KMU-351 Paveway I laser-guided bomb, 86
Kontum, South Vietnam, 12
Korean War, 14, 25–27, 29, 31, 37–39, 51, 54, 59, 68, 70, 72, 76, 90, 93, 95, 112; and air superiority, 26, 38, 90–91; and China, 90; and electronic countermeasures, 74–76; and North Korea, 25–27, 72, 76, 90; and radar guided weapons, 75–77; and South Korea, 25; and Soviet Union, 90; and United States Air Force, 27, 90
Kuwait, 102

Lamb, Al, 80
Laos, 9–10, 18, 47, 87; and Pathet Lao, 8; and United States Air Force, 8
launch warning receiver WR-300, 78
Lead-In Fighter Training Program, 103–104, 109, 112
Lemay, Curtis, 23–24, 27
Lemoore Naval Air Station, 72
Lindley, Ernest K., 25
Locher, Roger C., 3–4, 8, 199
Lockheed: and AT-33A Shooting Star, 104; and C-130 Hercules, 11, 13, 89; and EC-121 Warning Star, 46; and EC-130 Compass Call, 88, 102; and F-80 Shooting Star, 31; and F-104 Starfighter , 23, 46–47; and RT-33 Shooting Star, 8; and SR-71 Blackbird, 18; and U-2, 14, 18, 69, 76
Lodge, Robert A., 3
Loh, John M., 104–105
Luftwaffe, 19, 21, 34, 111
Lundquist, Kenneth R., 47

McBride, William P., 100
McConnell Air Force Base, 104
McDonnell Aircraft Corporation, 54–55, 65, 82, 85; and F-4 Phantom II, 3–8, 14–15, 23, 44–46, 49, 52, 54–65, 69–70, 81–82, 85–87, 89–90, 93, 95–98, 100–101, 103–104, 106, 108–12; and F-101 Voodoo, 23, 46–47; and RF-4C Phantom II, 9, 47; and RF-101C Voodoo, 8–11, 47
McDonnell-Douglas Aircraft Corporation, 108; and F-15 Eagle, 15, 44, 102, 108–12; and KC-10A Extender, 102
McLarren, Robert, 36
McMaster, H. R., 16
MacNamara, Robert S., 16–17, 28, 55, 107
Maginot Line, 22
Malaya, 27
Mandrel radio transmitter, 75
Martin R-57 Canberra, 9–10
Material Air Transport Service (MATS), 24
Maverick missile, 86
May Day parade, 68, 76
Me-262 Schwalbe, 34–35
Messerschmitt Me-262 Schwalbe, 34–35
Mientyukov, I., 69
MiG Alley, 31, 38–39, 112
MiG-15 Fagot, 37–40, 90
MiG fighter aircraft, 4–6, 14–15, 30, 39, 45, 49–56, 58–59, 62, 77, 83, 86, 89–90, 92–93, 95–100, 102, 105–107, 112
MiG-19 Farmer, 3–8, 43, 57, 63, 69, 93
MiG-17 Fresco, 9, 39–41, 43–45, 57–58, 62, 64, 83, 93, 99
MiG-25 Foxbat, 108
MiG-29 Fulcrum, 102
MiG-21 Fresco, 9, 47, 57–58, 93, 101–102
MiG-23 Flogger, 102
Mikoyan-Gurevich design bureau, 31, 39, 58; and MiG-15 Fagot, 38–40, 90; and MiG-17 Fresco, 9, 39–41, 44–45, 57–58, 62, 64, 83, 93, 99; and MiG-19 Farmer, 3–8, 43, 57, 63, 69, 93; and MiG-21 Fresco, 9, 47, 56–58, 93, 101–102; and MiG-23 Flogger, 102; and MiG-25 Foxbat, 108; and MiG-29 Fulcrum, 102

Military Assistance Command-Vietnam (MACV), 18; and Joint Movements Transportation Board, 11; and Traffic Management Agency, 11; and 834th Air Division, 11; and Command Operations Center, 11
Miller, Donald E., 100
Miramar Naval Air Station, 102
Mk-43 tactical nuclear weapon, 48
Mk-28 tactical nuclear weapon, 48
Momyer, William W., 59–62, 100
M-117 bombs, 49
Mosquito, 34
Moyers, William, 17
M61A1 Vulcan cannon, 7, 49, 61–62, 109

Nagasaki, Japan, 22
napalm, 69, 80
National Security Act of 1947, 23
Nazi party, 34, 68, 74–75
Nellis Air Force Base, 15, 80, 87, 92, 94, 96, 100–103
New Look defense policy, 13, 25, 29, 31, 112
Nichols, John B., 16, 52, 71–72, 97, 99
Ninth Air Force, 26
9th Tactical Reconnaissance Squadron, 76
Nixon, Richard M., 10, 18, 86
Normandy Invasion, 21
Norstad, Lauris, 22
North American Aviation, 31, 35–37, 39, 41, 78; and B-25 Mitchell, 75; and F-51 Mustang, 25; and F-86 Sabre, 31, 36–40, 42, 90–91, 93, 109, 112; and F-100 Super Sabre, 15, 23, 31, 40–43, 46, 57, 78–82, 91, 97, 107; and P-51 Mustang, 35–36, 42, 109; and XP-86 Sabre, 35–36
North Atlantic Treaty Organization (NATO), 68, 96, 102
North Korea, 25–27, 72, 76; and North Korean Air Force, 26, 39, 90
North Vietnam, 3, 8–10, 12, 14, 16, 18–20, 46–51, 69–70, 79, 83–84, 86–87, 89–90, 93, 96–97, 101, 105, 107; and Integrated air defense system, 4, 71, 74, 82, 84–85; and 19th Parallel, 86; and North Vietnamese Air Force, 7, 9, 14, 19, 31, 39, 45, 47, 49, 58, 62, 64–65, 86–87, 92, 98–99, 112; and North Vietnamese Army, 12
Northrop: and F-5 Freedom Fighter, 90, 101–102, 111; and RF-5 Tiger, 10; and T-38 Talon, 101–103, 109, 111

Office of Systems Development, 107
Okinawa, Japan, 12, 18
Olds, Robin, 39–40, 45, 56–59, 61–63
O'Mahoney, Joseph, 25
108th Guards Tank Army, 101
Operation Anvil, 21
Operation Bolo, 46
Operation Desert Storm, 102–103, 111
Operation Farm Gate, 8–9, 11
Operation Linebacker I, 10, 18, 57, 86
Operation Linebacker II, 10, 86–87
Operation Overlord, 21
Operation Sage Brush, 91–92

Pathet Lao, 8
Patrick, Joe, 16
Paveway laser guideline bomb, 86
P-51 Mustang, 35–36, 42, 109
P-47 Thunderbolt, 48
Philippine Islands, 18
Pike, Harry M., 22–23
Pitchford, John, 79–80
Plain of Jars, Laos, 8–9
Plei Me special forces camp, 12
Powers, Francis G., 14, 69, 76
Pratt & Whitney: and F-100 turbojet engine, 108; and J-57 turbojet engine, 42, 97; and J-75 turbojet engine, 44, 49
precision-guided munitions, 86
Project Corona Harvest, 67
Project Red Baron III, 57, 87, 99–100
Project Wild Weasel, 14, 50, 79–88, 106, 112

QRC-253-2 radar homing and warning system, 78

radar homing and warning (RHAW) system, 4–5, 72, 76, 78–80, 82, 84, 87–88
Radford, Arthur, 24
Raytheon: and AIM-7 Sparrow missile, 6, 52, 58–62, 97–98, 109; and AIM-9 Sidewinder missile, 33, 58, 60–62, 98–99, 101, 109

R-57 Canberra, 9–10
R-66 Destroyer, 76
R-26 Invader, 9
Red Crown sea-based control, 5, 56
Red Flag exercises, 15, 102–105, 112
Redland, 101–103
Red Square, Moscow, 76
Reid, William M., 26
replacement training units (RTU), 101
Republic Aviation, 48, 53, 84–85; and F-84 Thunderjet, 31, 48; and F-105 Thunderchief, 14–15, 23, 44–54, 57, 64–65, 70, 80, 82–85, 93, 99, 104, 106–107, 112; and P-47 Thunderbolt, 48; and Thunderstick 2 modification, 53
Republic of Korea, 12
Revolt of the Admirals, 24–25
RF8A Crusader, 69
RF-5 Tiger, 10
RF-4C Phantom II, 9–10, 47
RF-101 Voodoo, 8–11, 47
R-14 search and ranging radar, 48
Riccioni, Everest, 65, 106
Rice, Ray, 36
Richthofen, Manfred von, 55
Rickenbacker, Edward, 55
Rickman, Milton, 79
Ridgway, Matthew, 29–30
Ritchie, William, 106
Rockwell Industries. *See* GBU-15 electro-optical homing glide bomb
Rolling Thunder, 8, 21, 57, 86
Rostow, Walt, 17
Royal Air Force, 34, 42, 74
Royal Saudi Air Force, 111
RT-33 Shooting Star, 8
rules of engagement, 16, 18, 54, 87
Rusk, Dean, 17

Sabre 5, 42
Sabre 6, 42
Saigon, 18, 61
Sandelius, Edward, 79
SA-1 surface-to-air missile, 68
Saturn V rocket, 108
SA-2 Guideline surface-to-air missile, 4–5, 14, 50, 53–54, 68–70, 76–84, 86–87
SC-47 Skytrain, 8
Scott Air Force Base, 90
2nd Air Division, 18
SEE-SAMS (B) passive warning sensor, 82
Seith, Louis T., 48
Seventh Air Force, 18, 59, 83–84, 87, 99
Sexton, Michael, 110
Shallcross, Henry, 67, 89
Sharp, Ulysses S. Grant, 17–18
Shaw Air Force Base, 76
Shaw, Robert L., 90
Shrike missile, 81–85, 88
Sidewinder missile, 33, 58, 60–62, 83, 88, 98–99, 101, 109
Sikorsky. *See* HH-53 Super Jolly Green Giant
Simler, George B., 17
16th Reconnaissance Squadron (16th Ferret Squadron), 75
65th Aggressor Squadron, 101–102
64th Aggressor Squadron, 101–102
small arms fire, 14, 53, 70, 73
Smallwood, John, 4–8
Smith, John C., 54
South Korea, 25
South Vietnam, 9–12, 18, 86; and South Vietnamese Air Force, 10
Soviet air defense simulator, 79
Soviet Union, 15, 22, 30–31, 53–54, 57–60, 65, 69–70, 77, 81, 96–97, 101–102, 112; and atomic weapons, 22–23; and covert aid to Laos, 8–9; and radar guided weapons, 75–76; and Soviet Air Force, 97; and surface-to-air missiles, 14–15, 68
Spaatz, Carl, 26–27, 34–35
Sparrow missile, 52, 58–62, 88, 97–98, 109
Speer, Paul H., 98–99
Sprey, Pierre, 106
Spick, Mike, 90
Spoon Rest radar, 68
SR-71 Blackbird, 10, 18
Standard ARM missile, 85, 88
Strategic Air Command (SAC), 4, 10, 13, 18, 23–25, 27–30, 77, 91, 104, 112
Sukhoi: and Su-9 Fitter, 69; and Su-27 Flanker, 102
Su-9 Fitter, 69
surface-to-air missile, 4, 14–15, 50, 53–54, 67–89, 102, 112

Suter, Richard M., 101
Su-27 Flanker, 102
SUU-16 Vulcan cannon, 61–62
Sverdlovsk, Soviet Union, 69

Tactical Air Command (TAC), 3–4, 8–9, 13–16, 21, 23–25, 27, 29–31, 41–42, 46, 51, 77, 90–93, 95, 99–101, 103–107, 111–12; and airlift, 11–13; and reconnaissance, 8–11
Tactical Fighter Weapons Center, 87, 100
Takhli Royal Thai Air Base, 16, 51, 79
Tan Son Nhut Air Base, 9–11, 18
Tartar surface-to-air missile, 85
Taylor, Maxwell, 16, 29–30
Tea Ball land-based intelligence agency, 56
Tet Offensive, 10–11
Texas Instruments, 81, 86; and KMU-351 Paveway I laser guided bomb, 86
T-41 Mescalero, 103
Thailand, 9, 82, 89
3rd Marine Amphibious Force, 18
Thirteenth Air Force, 18
13th Tactical Reconnaissance Squadron, 9
Thornal, Leroy W., 67, 89, 95, 104
Thornborough, Anthony M., 87
315th Air Commando Wing, 11
355th Tactical Fighter Wing, 16, 51
366th Tactical Fighter Wing, 61–62
Thunderbirds Aerial Demonstration Team, 51
Thunderstick 2 modification, 53
Tilford, Earl H., 64, 77
Tillman, Barrett, 16, 99
Tonkin Gulf, 4–5, 7, 50
Tonkin Gulf Incident, 69, 71
Top Gun, 102
Top Off program, 15, 101
Traffic Management Agency, 11
Trier, Robert, 79–80
Trieste, Italy, 27
Trotti, John, 55
Truman, Harry S., 21, 25, 29
T-38 Talon, 101–103, 109, 111
T-37 Tweet, 103
Tucker, Gerald, 99
Twelfth Air Force, 92
20th Tactical Reconnaissance Squadron, 9–10
23rd Tactical Training Detachment, 104
Tyndall Air Force Base, 101

Ubon Royal Thai Air Base, 62
Udorn Royal Thai Air Base, 9, 99
Underhill, Eugene H., 92
United States Air Force, 3–4, 8, 10–16, 18–19, 21, 23–25, 27, 29–31, 33, 36–42, 46–47, 51, 54–59, 62, 64–65, 67–70, 74–79, 81–83, 85, 87–112; and Air Command and Staff College, 22, 103; and Air Defense Command, 22, 24, 42, 77; and Air Research and Development Command, 42; and Air Staff Task Force on SAM Missiles, 78; and Air-to-Air Capabiliti es Improvement Program, 15, 100; and Air University, 103; and Air War College, 26; and Continental Air Command, 24; and Far East Air Forces, 26; and Fighter Weapons School, 92, 94–95, 100–101, 104; and Historical Research Agency, 49; and Korean War, 27, 90; and Material Air Transport Service, 24; and Office of Systems Development, 107; and Strateg ic Air Command, 4, 13, 18, 23–25, 27–30, 77, 91, 104, 112; and Systems Command, 106; and Tactical Air Command, 3–4, 8–9, 13–16, 21, 23–25, 27, 29–31, 41–42, 46, 51, 77, 90–93, 95, 99–100, 103–107, 111–12; and Tactical Fighter Weapons Center, 87, 100; and Thunderbirds Aerial Demonstration Team, 51
United States Army, 10, 12–13, 18, 24–25, 28, 35, 41–42, 91, 102; and special forces, 11–12
United States Army Air Forces, 22, 35–36, 75, 111
United States Department of Defense, 55
United States Department of State, 25
United States Marine Corps, 18, 30, 55, 64–65, 93, 97, 111–12; and seige of Khe Sanh, 10, 12; and 3d Marine Amphibious Force, 18
United States Navy, 3–5, 13, 15–16, 24–25, 28, 30, 40, 45–46, 55, 60–62, 64–65, 68–71, 81, 85, 89, 93, 95–98, 102, 107, 109, 111–12; and Bureau of Aeronautics, 54; and Carrier Task Force 77,

18; and Fighter Weapons School, 54, 102; and Revolt of the Admirals, 24–25
USS *Coral Sea,* 69
USS *Essex,* 97
USS *Hancock,* 99
USS *Independence,* 69
USS *Oriskany,* 70
USS *Ranger,* 107
USS *United States,* 24
U-Tapao Royal Thai Air Base, 18
U-2, 14, 18, 69, 76

Vandenberg, Hoyt, 23–24
VA-147 Argonauts, 107
VA-146 Blue Diamonds, 107
Vector IV radar homing and warning system, 78
VF-24 Fighting Renegades, 99
VF-211 Flying Checkmates, 99
Vinson, Carl, 24
Vought, 107; and A7 Corsair II, 15, 107–108; and F4U Corsair, 25; and F8 Crusader, 46, 54, 70–71, 97–99; and RF8A Crusader, 69

Wall, A. E., 34
Wallace, Ronald, 102–103
War Department, 8, 13, 35
Wasserfall surface-to-air missile, 68
Wassermann radar, 74
Welch, George, 36–37, 40–41
Wescott, William, 38
Westinghouse Corporation, 85; and AN/APQ-120 radar, 62; and ALQ-101 electronic countermeasures pod, 85; and APG/AWG-10 radar, 62
Weyland, Otto P., 29–30
Wheeler, Earle, 17
White, Edward, 79, 83
White, Thomas H., 28
Wild Weasel, 14, 50, 79–88, 96, 106, 112
William Tell exercises, 92
Wilson, Charles E., 24
World War II, 14, 21, 25–26, 45, 47, 68, 70, 74–75, 91, 94, 96, 98, 111; and air superiority, 21–22, 24, 112; and atomic warfare, 22; and electronic countermeasures, 75–76; and European Theatre, 21–22; and Germany, 19, 21, 34, 68, 74, 111; and Great Britain, 35, 68, 74; and Japan, 19, 112; and jet aircraft, 34–35; and Operation Anvil, 21; and Operation Overlord, 21; and Pacific Theatre, 22, 74–75; and radar, 74–75; and Soviet Union, 68; and United States, 8–9, 68
WR-300 launch warning radar, 78
Wurzburg radar, 74–75
Wyman, Richard, 70

XP-86 Sabre, 35–36

Yeager, Charles E., 39
Yen Bai Airport, 3

Ziemke, Caroline, 23, 27, 30, 91