# THE AERIAL DOGFIGHT: A VALID PART OF TODAY'S AND TOMORROW'S AIR WAR

A thesis presented to the Faculty of the U.S. Army Command and General Staff College in partial fulfillment of the requirements for the degree

MASTER OF MILITARY ART AND SCIENCE

by

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B.S., Texas A&M University, 1977

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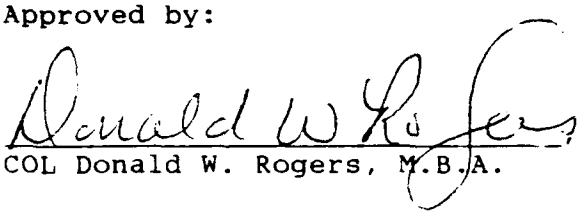

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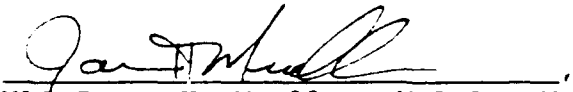

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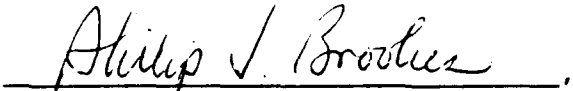

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ABSTRACT

THE AERIAL DOGFIGHT: A VALID PART OF TODAY'S AND TOMORROW'S AIR WAR.

An examination of four different conflicts and the factors that prevented technology from eliminating the aerial dogfight and the need for aircraft and their pilots to be able and ready to fight effectively in the aerial dogfight.

By Major Gerard A. Pelletier, USAF, 151 pages.

This study explores the evolution of technology and the aerial dogfight. It looks at how technology has tried unsuccessfully to eliminate the need for aircraft to engage in close-in aerial combat know as "aerial dogfights," to achieve air superiority or just defend themselves and survive from hostile aircraft. To show this, the study looks at four different conflicts: the United States in Vietnam, the Israelis in both the Yom Kippur War and Operation Peace for Galilee, and the British in the Falklands War. Four factors examined which vary in prominence in each of these conflicts are: financial restrictions, limitations of technology, rules of engagement, and the "fog of war."

The study concludes that technology as we know it today or in the foreseeable future will not be able to totally eliminate the aerial dogfight in a major conflict. As technology improves the effectiveness of weapons, it also improves the counters to these weapons. Financial restrictions in the form of budget constraints during times of peace have been a limiting factor to a country's technological advances prior to a conflict, and directly influence how a country will be able to fight at the start of any conflict. Rules of engagement and the "fog of war" further limit technology from being employed in its optimum designed application during a conflict.

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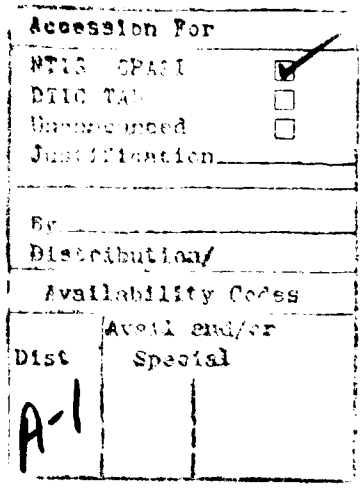

# CHAPTER 1

## INTRODUCTION

The aerial dogfight is a valid part of today's air war and will still be a valid part of tomorrow's air war. For the purpose of this thesis, the aerial dogfight arena is defined as that part of air-to-air combat in which opposing pilots are within visual range of each other. The aerial dogfight is defined as any air-to-air engagement within that arena. This thesis examines how technology has been unable to prevent aerial dogfights.

The factors examined in this thesis are technological limitations and outside influences that have limited technology from being employed in its optimum designed environment. These outside influences are financial restrictions, rules of engagement (ROE), and the uncertainty that occurs in war. This uncertainty in war will be referred to as the "Fog of War."

TECHNOLOGY AND THE HISTORY

OF THE AERIAL DOGFIGHT

Technology plays an important part in the evolution of air combat tactics. Weapons have advanced from hand-held rifles and pistols to very sophisticated radar-guided and heat-seeking missiles. On-board computers now aid the pilot in all facets of his mission. Advances in aircraft design and capabilities are equally impressive. Aircraft have progressed from having barely enough power to fly, to having the ability to fly more than three times the speed of sound. Air combat tactics have evolved tremendously since the days of the Wright brothers to take advantage of the increased capabilities afforded by technology.

The advances in technology are divided up into three eras. First, the evolution from the initial uses of the airplane up through World War II. During that period, technology concentrated mainly on aircraft design, although there were some important developments in the field of aircraft weaponry and the invention of radar. The second era in the evolution of technology and the aerial dogfight was the period after World War II to Vietnam. This period represented the advent of guided air-to-air missiles, nuclear weapons, and the unsuccessful attempt to eliminate the aerial dogfight through the use of these new technologies. The third era was the period from post Vietnam to the present. This last period

showed efforts still underway to try to minimize aerial dogfights, but proved that the aerial dogfight was to continue as a valid part of the air war. This period also introduced new technology that was almost immune to the guided missiles, which once again will force aircraft into an aerial dogfight to achieve air superiority.

## FROM THE BEGINNING TO WORLD WAR II

The first military use of air power was for aerial reconnaissance.[1] In 1912 in Libya, the Italians, trying to take Libya from the Ottoman (Turkish) Empire for their own colonization, employed airplanes to pick up information on Turkish troops and Libyan desert tribes. The Italian aviators even managed to drop primitive lightweight hand-held bombs from their aircraft at the Turkish troops and the Libyan tribes. Although this primitive bombing was not very accurate or effective, it did demonstrate the airplane could be used as an element of combat power.[1]

The first dogfights in World War I were the result of one side trying to deny the other side the use of air as an instrument of combat power.[1] The Royal Flying Corps Manual of June 1914 stated:

> It is not to be expected that aircraft will be able to carry out their duties undisturbed. In war, advantages must be fought for and the importance of aerial reconnaissance is so great that each side will strive to prevent the other making use of it.[1]

The first casualty of air-to-air combat occurred on October 5, 1914, when a French Voisin Type 3 of the French Air Service shot down a German Aviatik.[1]

The first dogfights were more of a jousting match, like the knights of old, with only two aircraft and their pilots using hand-held weapons with little success. In 1915, a noted French pilot, Roland Garros, remembered pre-war gun trials with aircraft where a fixed, forward-firing machine-gun was fitted with an interrupter gear. The interrupter gear enabled the machine-gun to be fired through the propeller arc by preventing the machine-gun from firing when the propeller blade was in line with the machine-gun muzzle. Mounting the machine-gun directly on the nose of the aircraft and firing through the propeller arc was desirable because it allowed the pilot much greater accuracy in aiming his gun. The project was abandoned because faulty ammunition caused misfires and hit the aircraft's propeller blades.

The Germans, aware of the potential of the fixed, forward-firing machine-gun, had conducted similar trials with similar results. Raymond Saulnier in charge of the French trials had come up with an idea of fitting steel wedge-shaped deflectors to the vulnerable part of the propeller to deal with the misfires. However, this caused a loss of propeller efficiency and added strain to the engine. These penalties were felt to be unacceptable in peacetime. With World War I in progress, Garros asked Saulnier for the fixed, forward-

firing machine-gun with the interrupter gear to be fitted on his aircraft. After some discussion, the fixed, forward-firing machine-gun was mounted on Garros aircraft with only the deflectors fitted to the propeller blades. On April 1, 1915, Garros in his Morane-Saulnier Type L attacked a German Albatros and shot it down. During the next two and half weeks Garros shot down four more German aircraft. On April 18, Garros crash-landed behind the German lines, becoming a prisoner of war, allowing the Germans a chance to examine his machine.

The German engineers, under the direction of Anthony Fokker, a Dutch designer, were able to come up with a better solution for the fixed, forward-firing machine-gun, a synchronization gear. This synchronization gear was promptly fitted to one of their aircraft, the Eindecker.[6] By the summer of 1915, the fixed, forward-firing machine-guns were on many of the aircraft of both sides of the war. This significant increase in aircraft shooting accuracy caused aerial dogfights to start to change in shape from those early jousts to turning, slicing, and looping engagements between two aircraft.[7] The romantic aerial, turning dogfights with aircraft everywhere did not come until later in World War I in 1916.[8]

The objective of these aerial dogfights was to maneuver to a position behind the opponent to shoot him down. If the two aircraft passed each other head-on (high aspect),

both aircraft would only have a passing glimpse of a shot (a snap-shot) at each other. But if one aircraft could achieve a position behind the other aircraft, he would normally have a longer time to align his shot, thus improving the chance of shooting down the adversary.[9] Another advantage of maneuvering to the opponent's rear was, if the opponents aircraft's guns only shot forward, this meant that he could not shoot at you while you were behind him.[10]

Later in World War I, German, French, and British aviators discovered that fighting in numbers was far better and offered more protection than fighting as a single. By mid-1915, the Germans began sending up an escort airplane with their reconnaissance aircraft for protection. Oswald Boelke, a German escort pilot who would become one of the greatest aerial tacticians of the time, discovered that he was unable to concentrate on an attack and keep a good lookout for other enemy aircraft at the same time. To answer this dilemma, German escorts started flying in pairs, one to guard the other's tail.[11] The Royal Flying Corps, concerned about the advances the Germans had made in both tactics and aircraft, issued the following order on January 14, 1916:

> Until the Royal Flying Corps are in possession of a machine as good as or better than the German Fokker, it seems that a change in the tactics employed becomes necessary . . . . In the meantime, it must be laid down as a hard and fast rule that a machine proceeding on reconnaissance must be escorted by at least three other fighting machines. These machines must fly in close formation, and a reconnaissance should not be continued if any of the machines becomes detached . . . . From recent experience it seems that the Germans are now

> employing their aeroplanes in groups of three or four, and these numbers are frequently encountered by our aeroplanes.[12]

Even though airplanes were now flying in groups or formations, they still tended to fight mainly as singles once in a dogfight. However, this practice was potentially dangerous in aerial dogfights where numerous aircraft were involved by both sides. An October 1916 German Air Service Order stated, "The present system of aerial warfare has shown the inferiority of the isolated fighting aeroplane . . . ," suggesting the beginning of a new phase of aerial dogfighting.[13] The new phase saw airplanes within large formations of airplanes now fighting as dedicated teams in support of each other. The new phase showed that staying in a protracted aerial dogfight was undesirable, because the longer it took to shoot an adversary in a multiple aircraft environment, the higher the probability that a reinforcing aircraft would shoot the attacker.[14]

From World War I, the aspects of speed, range, maneuverability, and firepower were the most important considerations in aircraft design. Technological advances in these aspects were changing air warfare dramatically. Increasing aircraft performance enabled aircraft to fly faster, higher, and farther. By the late thirties aircraft had advanced from the likes of the British Sopwith Camel, whose speed was 113 miles per hour (mph)[15], with a ceiling of 15,000 feet (ft)[16], and a maximum range of 200 miles[17], to

aircraft such as the German Messerschmitt Bf-109E with a speed of 357 mph, a ceiling of 32,800 ft, and a range of 348 miles.[1] Even the bombers had made great strides from the British DeHavilland DH-4 with a speed of 108 mph, a ceiling of 13,500 ft, and a range of 400 miles[1], to the B-17 with a maximum speed of 317 mph, a ceiling of 36,600 ft, and a range of 2000 miles.[1] These technological advances increased the fighter pilot's work load to visually scan more of the sky. The increase in aircraft speed, meant a defending fighter pilot would have less time to find aircraft transiting his area. The ability of aircraft to fly higher, required a defending fighter pilot to scan twice as much sky than before. And the increase in range allowed attacking bombers to attack deeper into the defender's country, or take a less obvious route to the target. It was becoming harder for the fighter pilot to detect, by visual means alone, any incoming fighter or bomber force with the increased airspace work load.[1]

These increases in aircraft performance necessitating a need to be able to scan more of the sky did not go unnoticed. In the late thirties a new technology called radar was invented, which enabled defensive forces to detect incoming threats beyond the range of the unaided human eye.[1] Since speed, altitude, weather, and night flying were limiting factors of the human eye, defense forces would become dependent on this new technology.

Radar works by transmitting a radio wave out and then listening to see if that wave bounces off (or is reflected by) anything. The reflected radar energy is then picked up by the radar as an echo. To determine the range of the echo, the radar then measures the time the radio wave took from transmission to reception. The direction of the echo is measured in terms of the angle between the echo and a horizontal reference direction such as north or, as in most airborne radars, the longitudinal reference axis of the aircraft's fuselage. This angle is resolved into a horizontal and vertical component. The horizontal component is the target's azimuth, and the vertical component is the target's elevation. The echo information is then displayed on the radar scope as a target for the radar operator to use."

The early radars were big and had to be located on the ground. Ground radar operators, through radios, would vector aircraft toward the enemy aircraft until the pilots could see the enemy." Aircraft began carrying radios by the late twenties allowing flight to ground communications for real time information, and inter-flight communications. The initial radios had problems with speech distortion and much practice in listening was necessary. To counter this problem the Royal Air Force (RAF) started using code-words as an unmistakable verbal-shorthand. For example, the RAF used the word 'bandit' for a known enemy aircraft, and the word 'bogey' for an unidentified aircraft. With time the radios improved,

but listening errors were still possible so the verbal-shorthand stayed. This ability to communicate by other than just visual signals in the air added to the effectiveness of aircraft flying in formations.[11] The radio became invaluable to pilots using the new technology, radar, giving the ground radar operators a way to vector friendly aircraft towards enemy aircraft.

By 1940, improvements in radar technology in terms of size and power requirements allowed aircraft to carry their own radars. The first accredited kill by a radar equipped fighter was on the night of November 7, 1940 by Flight Officer Ashfield in a Bristol Beaufighter.[16] The first American aircraft designed specifically as a night fighter with a radar was Northrop's P-61A Black Widow. The Black Widow entered service in May of 1944, and was used to destroy several enemy aircraft before WW II ended in 1945.[17] This innovation of aircraft being able to carry their own radar would later help lead to the radar-guided missile.[18]

As with any new military technology, the counter to these technologies would soon follow. In the 1940's, it was quickly discovered that the radar devices did not have to be destroyed to be rendered ineffective. Simply neutralizing radar signals by counterfeit, distortion, or muffled electronic noises was sufficient. This was done by the use of electronic jammers or chaff. The age of Electronic Warfare (EW) had arrived.[19]

The early electronic jammers were not directed at disrupting or deceiving the radio waves of a radar, but rather at disrupting and deceiving the radio waves the Germans were using for navigation in 1940 to bomb England at night with pinpoint accuracy. These early electronic jammers were nothing more than hospital diathermy sets ordinarily used for cauterization. The sets were adjusted to the frequencies of the German radio navigation beams and emitted a cacophony of noise that drowned out the navigation beam of the German pilots. Next the British used high-frequency radio sets to produced a signal on top of the radio navigation beam, which led the German pilots to drift off course. The British were very effective with these early electronic jammers, causing the German pilots to drop their bombs relatively harmlessly in the English countryside."

Chaff was discovered in 1942 by both the British and the Germans. Chaff is thin, light strips of foil or metalized fiber scattered in the air by aircraft, to hide targets or otherwise confuse the operation of an enemy's radar. The length of these strips was usually made equal to the wavelength employed by the radar the chaff was to be used against. This maximized the chaff's radar cross-section, thus creating false signals on the enemy's radar scope." Chaff was so effective against radar and so simple to make that neither the British nor the Germans would use this development initially for fear the other side would have no trouble

figuring it out. The Germans were so scared the British might figure out chaff if they used it that Reich Marshal Hermann Goring ordered the test reports on chaff destroyed and all experiments with it ceased immediately. The British did finally employ chaff for the first time on the night of July 24, 1943 with devastating effects. The British flew a mammoth raid of 746 Allied bombers on the port of Hamburg and only lost twelve aircraft. But the British only used this chaff after the Americans had developed an airborne radar immune to the effects of chaff."

Even with the advent of EW in World War II, little had changed from the aerial dogfights which were seen at the end of World War I. The main difference in aerial dogfighting between these wars was the tactics used to enter aerial engagements. Tactics were designed to give aircraft formations an offensive advantage when entering a fight."

An example of this was the line-a-breast formation flown in pairs by German Me 109 pilots. The advantages of this formation were three-fold. By flying line-a-breast, each pilot could concentrate his search pattern inward, allowing each to better watch the other's blind spots behind and below. If attacked, the German pilots would turn their line-a-breast formation to place the enemy attacker between them, allowing one of them a shot at the enemy attacker. And, if the lead aircraft launched an attack, the wingman was in a good position to support and cover his leader."

These tactics tried to minimize the number of protracted engagements and decrease the attacker's vulnerability to being attacked. Due to the fact that the only weapon available to kill an opponent was still the machine-gun (short of ramming), the most effective tactic was still an unobserved attack to the enemy's rear.[11]

The machine-gun had restrictive shot parameters, which required precise aiming to achieve a hit on any object whether the object was flying through the air or stationary on the ground. If an attack was observed, it would normally lead to a protracted aerial engagement because the pilot being attacked would try to defend himself by denying the attacker the parameters necessary to effectively employ his gun.

The evolution of the aerial dogfight up through World War II saw four important advances. First, tactics evolved to minimize the time required to shoot down an adversary by trying to arrive unobserved to a favorable position from which to shoot. Second, aircraft started flying in mutual support of one another for the purpose of maximum survivability. Third, this era in the evolution saw the invention of radar, which will be prominent in the developments of the next era. Last, technology concentrated on improvements in aircraft design and performance. Aircraft weaponry saw little improvement, as the only means of shooting down another aircraft by the end of World War II was still the machine-gun. This meant that aircraft at this point of the evolution still

had to enter the aerial dogfight arena to shoot down another aircraft.

## POST WORLD WAR II TO VIETNAM

From both World Wars, a lesson learned about aerial dogfighting was that when both sides were fighting in numbers, the longer the dogfight lasted, the higher the probability of the attacker being shot by another enemy aircraft. This problem of the aerial dogfight becoming a protracted engagement if both sides saw each other, was due to the machine-gun being the only available kill mechanism rather than tactics[11] and was realized prior to the Korean War.[11] Research and development was conducted to find another weapon to give the fighter pilot a better tool to destroy his aerial adversary. The idea was to kill the opponent with minimum maneuvering, thus making the attacker less likely to be in a protracted aerial dogfight. In turn, this would make the attacker less vulnerable.[11] This research would not produce anything until after the Korean War. Therefore, the Korean War saw little change from previous wars, because none of the new guided missiles were available yet.[11]

Following the Korean War, research and development succeeded in producing a new generation of sophisticated guided or homing missiles by the mid fifties.[11] The two main categories, depending on the type of guidance system employed,

were heat-seeking (infra-red or IR) missiles and radar-guided missiles. The purpose of these missiles were to track and destroy a flying target.[1]

Early heat-seeking missiles still had to be launched from behind the adversary. The heat-seeking missile worked by homing in on the heat emissions from the target aircraft. The early heat-seeking missiles needed to be behind the enemy aircraft to see the hot engine exhausts of the target aircraft.[1] The launch parameters were greater (less restrictive) than those of the gun in two areas. They had greater range, about two miles[1], and could be launched from multiple positions behind the adversary. The increased range meant the attacker did not have to get as close to his opponent to kill him, increasing his chances for an unobserved shot. The ability of the missile to be launched from multiple positions was due to two technological advances. First, the missile had its own seeker head which allowed the missile to see and track the target if it was within the field of view of the seeker. Second, the missile had the ability to maneuver itself through externally mounted movable fins, called canards, toward the tracked target.[1] These two improvements, the missile's self contained guidance and maneuverability, along with the missile's increased range, allowed the pilot much more flexibility in aiming the missile over the machine-gun. This was because once the bullets in the machine-gun are fired they had no ability to see the

target, track the target, or change course and go after the target. Thus with the missiles, less maneuvering and less time would be required to kill an adversary in a typical dogfight, if any dogfight occurred at all. But these early missiles still had to be launched from behind the adversary.[11]

The most widely produced heat-seeking missile of the fifties and sixties was the Air Intercept Missile (AIM) 9B Sidewinder because it was a simple and cheap IR (heat-seeking) missile to deploy. It became operational in 1956,[11] required minimum cockpit switch actions, and was simple to fire. With a short, two mile range, weapon employment was very constrained. Another weak point was its vulnerability to home in on the sun, flares, or any other strong heat source other than the target. The initial AIM-9 Sidewinders had limited maneuverability, since they were designed for use in naval fleet defense against incoming bombers.[11] For these reasons, the early Sidewinders were restricted to tail chase attacks and only in good weather to ensure the missile locked onto the enemy's hot exhaust.[11]

The radar-guided missile was the second missile developed in the mid fifties.[11] The radar-guided missile homed on reflected radar energy off the target aircraft. This meant the missile could be launched at an aircraft from any angle, including head-on. The radar-guided missile also had a greater range (initially five to eight miles) than both the

heat-seeking missile (two miles) and the gun (half a mile), permitting an engagement from beyond visual range (BVR)."

The AIM-7 Sparrow was the most common radar-guided missile used during the sixties. The AIM-7 Sparrow became operational in 1956." The fighter aircraft's radar illuminated the target with radar energy and the Sparrow would home in on the reflected radar energy. Although radar-guided missiles cost more than heat-seeking missiles, the sophistication and range of the AIM-7's Sparrow made it a beyond visual range (BVR) missile. Later improved versions of the AIM-7 Sparrow produced in the late sixties allowed ranges up to 25-28 miles."

However, the early AIM-7 Sparrow had two major drawbacks. First, the missile was initially designed to stop bombers and did not have the maneuverability needed to hit a maneuvering fighter." Second, the missile was vulnerable to jamming. In fact, during the Vietnam era, it was not unusual for a USAF fighter to expend 4 to 8 missiles to destroy one Mig."

During the development of these new guided missiles, the development of fighter aircraft capable of carrying and delivering atomic weapons in 1950, along with a 1951 Air Force study called Project Vista, influenced Tactical Air Command's (TAC) focus, emphasis, and direction. Project Vista concluded that, while the battle for air superiority was very important, it could be achieved by a concentration of tactical atomic

weapons against Soviet airfields. The report also concluded that aerial dogfighting was an inefficient method of achieving air superiority.[11] Aerial dogfighting, it appeared, had lost its viability in this new era of atomic weapons.

With the Project Vista report and the advent of these new missiles, as Mike Spike says in his book Fighter Pilots Tactics; The Techniques of Daylight Air Combat, "many pundits predicted the end of the manoeuvering dogfight." These experts assumed that aerial combat would become a contest of technology instead of tactics with the opponents never seeing each other.[12]

This caused a shift in priorities of aircraft capabilities toward the nuclear delivery mission.[13] During this period, the USAF developed the F-105, emphasizing speed, penetration capability, and bomb load. The aircraft was not very maneuverable and had no real air-to-air capability.[14]

The growing Soviet nuclear bomber threat affected the design of U.S. air superiority fighters. This led to an emphasis in all-weather fighter interceptors for air defense against bombers, rather than in tactical aircraft.[15] The new prevailing view of air warfare was reflected in aircraft development. The new fighters, like the F-102, F-106, and F-4, were designed for speed and employment of long-range missiles, and not maneuverability.[16]

The need to enter the aerial dogfight had finally been eliminated, or so it was thought.[17] And thus, needing an

internal gun on an interceptor aircraft was considered obsolete by the Department of Defense. In 1964, Secretary of Defense Robert S. McNamara even went so far as to say; "In the context of Modern Aerial Warfare, the idea of a fighter being equipped with a GUN is as archaic as warfare with bow and arrow."[11]

This philosophy was evident in the design of the services' interceptors of the mid-fifties and early sixties, the Air Force's F-102, F-106, and the Navy's F-4. The services' initial operational requirements given to the contractors of all three aircraft did not require a gun.[12] The F-102 became operational in 1956[13] and was built as an interceptor whose only weapons were an all missile armament of six Hughes Falcon missiles of either radar-guided or heat-seeking capabilities.[14] The F-106's requirement stated that it would carry one MB-1 air-to-air atomic rocket and four Hughes Falcons. The F-106 became operational in 1959.[15] Later, the F-4 Phantom was developed to carry the newest air-to-air missiles of the time. It first became operational for the U.S. Navy in 1961[16] and for the U.S. Air Force in 1963.[17] The F-4 Phantom could carry four radar-guided AIM-7 Sparrow missiles and four heat-seeking AIM-9 Sidewinder missiles.[18]

The F-4 was initially designed as a carrier-based, high altitude, high speed, fleet defense interceptor.[19] It was larger than any previous fighter built to accommodate eight air-to-air missiles and its air-to-air radar.[20] Its original

design had never been intended for aerial dogfighting, but was for naval fleet defense." The F-4 also utilized an additional crew position to help operate new systems, including a better air-to-air radar. The United States Air Force (USAF) and Navy were so convinced these new technologies had eliminated the requirement for the aerial dogfight, the original F-4 Phantom jets were produced without an internally mounted gun."

In the fifties and sixties, the jet engine and air-to-air missiles changed air warfare. The desire for high-speed and long range mixed with airborne radars, missile armament and all weather navigation gear increased the weight of USAF fighters six fold between 1944 and 1964. The weight of USAF bombers increased four times." All of this meant not only larger and more expensive aircraft, but bigger radar targets. Radar was now capable of picking up aircraft at greater ranges. This meant that even with increased airspeeds, initial radar detection times stayed fairly constant with the larger aircraft because of their larger radar cross section (RCS)."

RCS is determined by measuring the amount of energy reflected from the aircraft toward an observer. The RCS is a factor relating to the power of the radar energy that a target scatters back in the direction of the radar relative to the power density of the radar's transmitted radar energy at the target's range. It takes into account the cross-

sectional area of the target as viewed by the radar, the target's reflectivity, and its directivity. The directivity of a target is the degree to which it scatters energy back in the direction of the radar."

The next step of the evolution was the development of studies on EW, early detection of aircraft and, in 1953, minimizing an aircraft's radar cross section (RCS)." To deny radar the ability to see the larger RCS, the focus on tactics and jamming to foil the radar occurred in the late fifties and early sixties.

New tactics such as low flying and terrain masking to avoid ground radar's line of sight were employed. These new tactics also defeated airborne radars because of ground clutter problems on the early airborne radars. Flying in formation with one aircraft in trail of another also created confusion on the accuracy of the aircraft's range on airborne radars too."

The jamming consisted of both active and passive jamming technics, which in the electronic warfare community is known as electronic countermeasures (ECM). ECM are those actions taken to defend one or more aircraft from an enemy's air or ground radar-guided missiles." Active electronic jammers are composed of electronic transmitters using noise or disruption of amplitude or frequency signals to impair a radar's normal mode of operations. There are several ways to disrupt a radar's picture. A few ways to interfere with

radars are saturation of the radar's receiver, information denial, and jamming all the radar frequencies."[6] And passive electronic jamming is the use of chaff. Chaff is thin, light strips of foil or metalized fiber that are scattered in the air to hide targets or otherwise confuse the operation of the enemy's radar by creating false signals on the enemy's radar scope."

The Vietnam conflict witnessed the first attempts to do away with the aerial dogfight using the new technologies. The initial Vietnam engagements with the F-4 unfortunately showed that the aerial dogfight was still alive and well. From August 1967 to February 1968, the North Vietnamese lost only five Migs while downing eighteen USAF aircraft,[7] even though the Migs had no radar-guided missiles.[8] This meant the Migs had to enter the aerial dogfight arena to employ their weapons and achieve their kills. The Migs proved to be more nimble and agile than the big, fast F-4 in the aerial dogfight arena."

The radar-guided and heat-seeking missiles had two general design problems. Initially, the problem was thought to be growing pains of the new weapon system. However, the first problem was that the missiles had originally been designed to go against bombers, and not the highly agile Migs. This proved out as the probability of kill (PK) of the new radar-guided missiles (AIM-7s) did not significantly improve over time. So, the F-4 crews were then told to shoot two

missiles, instead of just one, to improve their PK. Unfortunately, even with this new shot doctrine the PK rose only a little and still remained under 50%.[11] This new shot doctrine was also tried with the latest version of the heat-seeking (AIM-9, Sidewinder) missiles with similar results encountered.[11] After Vietnam, as the maneuverability of the missiles improved, so did their PK, as will be noted in Chapter Three in both the Israeli and British experiences with modern air-to-air missiles.

The radar-guided and heat-seeking missiles had a second general design flaw. The missiles had a minimum firing range to ensure safe separation from the launch aircraft before the missile armed. This meant that a missile launched too close to the aircraft being attacked would probably not explode, even if the missile hit the enemy aircraft. This arming delay was so the missiles would not blow their own aircraft out of the sky by accident (in itself, not a bad idea). Since the initial design of the missiles had been for defense against incoming bombers and not with the maneuvering environment of the aerial dogfight in mind, the problem of the minimum range of the missiles had not been adequately addressed. This minimum range left the fighter pilot with a void in an aerial dogfight where he did not have anything he could shoot, even if the target flew right in front of him.[11]

From the lack of success of the U.S. in the air-to-air arena, the fighter force tried to identify and correct the

shortfalls in U.S. air superiority capabilities and mission. The results of this effort yielded several changes to the F-4. A 20mm gun pod was added to the F-4 and first used in combat in May 1967." Later versions of the F-4 in 1968 were produced with an internal 20mm gun. Leading edge slats and a slotted tail were added to later versions of the F-4 in 1972 to improve the aircraft's maneuverability to counter the more agile and nimble Migs."

During the period from 1968 to 1972, intentional air-to-air combat was prohibited in North Vietnam. This was because of a bombing halt in North Vietnam directed by the President of the United States." During this time, neither the Navy nor the Air Force allowed their pilots to go after Migs in North Vietnam." If the North Vietnamese flew into South Vietnam, then the U.S. pilots were still cleared to engage them over South Vietnam." The North Vietnamese pilots seldom ventured south and there were no Mig kills during this period."

When the air activities resumed in North Vietnam in 1972, the more maneuverable F-4 with the internal gun and maneuvering slats would prove itself a formidable dogfight aircraft. This new F-4 accounted for twenty-one of the forty kills achieved during the last nine months of the conflict. Ten of these kills were in the aerial dogfight arena, with five of them by the new internal 20mm gun."

The period from post World War II through Vietnam demonstrated one extremely important lesson learned. Prior to Vietnam, the United States did not foresee itself engaging in any kind of conflict in which the aerial dogfight would be a valid part of that conflict. Vietnam showed the United States that the aerial dogfight was still very much a valid part of an air war.

## POST-VIETNAM TO PRESENT

Today's aircraft performance in the realm of speed, range, maneuverability, and firepower are as an important aspect of aerial dogfights as they were in World War I when aircraft first started shooting at each other."[1] The technological advances in these areas have been dramatic since those first war birds of 1914. The speed capability of aircraft has increased from less than 100 knots at the start of World War I", to over three times the speed of sound today."[1] There are four reasons that speed is important in the aerial dogfight arena. First, superior speed in an engagement gives the attacker the advantage of being able to run down an opponent if he tries to run away. Second, it allows the attacker the ability to disengage and leave an opponent who is obtaining an offensive advantage."[1] Third, speed also gives you the ability to rush to an engagement to aid a buddy in trouble or to down an enemy bomber before he can drop his

bombs. And fourth, speed complicates a gun solution by making it harder to hit a faster target with bullets because of the increased lead required when aiming.

Range and endurance have also increased dramatically over the first fighter aircraft of World War I. With the advent of inflight refueling, range and endurance are limited today to the pilot's own endurance."[11] In an aerial dogfight arena, the importance of range and endurance is that they allow aircraft to cover more area, escort bombers farther, and stay in an aerial dogfight longer, if needed. The last point is especially valid if the pilots and aircraft of both sides are approximately equal and are engaged in a fairly neutral (neither side winning) aerial dogfight. The loser will probably be the one who has to leave the fight first for fuel. This is because the pilot who leaves first will allow the other pilot to maneuver his aircraft to a favorable position to fire his weapons.

Increases in aircraft structural strength technology have improved aircraft maneuverability by allowing aircraft to withstand increased stresses encountered during high performance maneuvering."[12] Maneuverability is one of the most important features an aircraft needs to be effective in an aerial dogfight. If an aircraft is more maneuverable than his opponent, he can turn a defensive or neutral situation into an offensive situation for himself. If a pilot starts out

offensive, he should normally stay offensive, no matter what his opponent does.

Computers greatly enhance aircraft capabilities, while reducing pilot work loads. Maneuverability has been dramatically changed with the introduction of fly-by-wire technology. The technology allows an aerodynamically unstable aircraft to fly. Computers control the instability and create an artificial stability." The advantage of unstable aerodynamic designs are increased turning performance capabilities not previously attainable. i.e., 9G's of lateral acceleration and turn rates in excess of 20 degrees per second."

Computers now help pilots analyze their radars, tell them when a radar is looking at them, and let them know when they have had a system malfunction. Today's aircraft computers even help the pilot aim his shots, making them more accurate than ever."

Which is more important of these features, speed, maneuverability, range, and endurance, is a question still being evaluated today. Range and endurance are important, but are not considered as important as speed and maneuverability for an air superiority fighter aircraft. In World War I, the German aircraft were more agile and maneuverable, while the British and French aircraft were faster.[11] The German Ace, Adolf Galland, General of the Luftwaffe with 104 kills in World War II, said: "For escorting bombers, maneuverability

is important, otherwise speed, acceleration, and climb are very important."[101]

The American Ace, John C. Meyer, with 26 kills in World War II and Korea, said: "I'd take speed above maneuverability."[102] A view which is shared by many that speed is more important than maneuverability. Tex Hill, Flying Tiger's second highest scorer with 18 1/4 kills, agreed with Meyer's assessment when Hill said: "A fighter's speed is more important to me than its maneuverability."[103]

Even though speed appears to be the most desired trait in a fighter by many fighter pilots, the importance of maneuverability is undeniable. In World War I, 95% of the kills made were in maneuvering dogfights, while the other 5% were made in hit-and-run combat. In World War II, the percentage dropped to only the low sixties. But, in both Korea and Vietnam, the percentage of aircraft killed in maneuvering dogfights was above 80%.[104]

The lessons the U.S. learned from previous wars and relearned in Vietnam in respect to aerial dogfights is evident in the design of their fighters following Vietnam. Both the F-15 and the F-16 are fast, highly maneuverable, and carry internal guns to complement their air-to-air missiles. The F-15 entered the USAF inventory in November 1974. Capable of speeds two and a half times the speed of sound, the F-15 was designed for unrivalled capability in aerial dogfighting. The F-15 is armed with an internal 20mm gun and capable of

carrying and firing any air-to-air missile in the USAF inventory, although its basic load consists of four AIM-9 Sidewinder heat-seeking and four AIM-7 Sparrow radar-guided missiles.[115] The F-16 initially entered the USAF inventory in August 1978. With speeds in excess of twice the speed of sound, the F-16 was designed as a lightweight fighter. The F-16 is one of the most maneuverable fighters in the world today. Like the F-15, the F-16 carries an internal 20mm gun and the most current versions of the aircraft are capable of carrying and firing any air-to-air missile in the USAF inventory.[116] Which is more important speed or maneuverability will probably continue to be disputed, but what can not be disputed is the importance of both in today's air war. Vietnam relearned the validity of the gun in the aerial dogfight and that the new high-tech missiles complemented the gun, but did not replace it. This aspect of the Vietnam conflict will be further addressed in Chapter Three.

To complement the new high-tech jet fighters, in the late 70's and throughout the 80's, new generations of medium and long range radar-guided missiles appeared. These missiles improved (shortened) the minimum range from which they could be fired and still arm. Examples of these missiles included improved versions of the U.S. AIM-7 Sparrow, the U.S AIM-54 Phoenix, and the U.S. AIM-120 AMRAAM. Improved navigational guidance systems, weight reductions, and improved aerodynamics made them harder to defeat by maneuvering or jamming.[117]

Furthermore, with second and third generation seeker heads, the Sidewinder (AIM 9) became an agile dogfight missile, as improved proximity fuses and warheads increased the kill probabilities. Development of an all aspect IR (heat-seeking) missile with better heat discrimination made it more difficult to defeat with flares or other artificial lures. These latest heat-seeking missiles definitely are lethal weapons for aerial combat in the 90's.[11]

The desire to eliminate the need for the aerial dogfight has not changed today. Newer, better, and more reliable radar-guided and heat-seeking missiles are produced today with greater launch ranges and maneuverability than ever before. But even as these great strides are being made in missile technology, the counter measures to defeat them are not far behind.

Today stealth technology is making the radar-guided weapons of yesterday and today obsolete. The very nature of stealth (low-observable) technology has changed. Stealth has entered the picture and applies to all ways of making aircraft less detectable to the enemy's air and ground radars. i.e., aircraft material, engine inlets, detail design, etc.[11] An example of this is the recently released data about the F-117A stealth fighter whose average RCS is believed to be in the 0.001 to 0.01 square meter range. This small a RCS will deny radars the ability to see, much less track, the aircraft. This means, if the aircraft can not be seen by radar, radar-

guided missiles can not be used against it. The F-117A has also been designed to minimize its heat signature, thus reducing the range a heat-seeking missile will be able to see the stealth fighter.[11] These advances in stealth technology, negating the radar-guided missile and minimizing the range of the heat-seeking missile, make the aerial dogfight a valid part of today's and tomorrow's air war.

## OUTSIDE INFLUENCES

### RESTRICTIONS TO AERIAL COMBAT

There are two main restrictions an air force may encounter which will have a significant impact on the type of air war an air force will fight. These two restrictions are financial and rules of engagement (ROE). Either of these restrictions by themselves or together can force aircraft into aerial dogfights.

Financial restrictions can severely dictate how a conflict may be fought by limiting the resources available. Typically, military cutbacks in funding generally occur when countries are at peace. These constrains force military planners into making trade-off decisions on system configurations and numbers of systems. In turn, these financial decisions have a definite impact on how well the military will be able to fight in a particular conflict. When a country is actively engaged in a conflict, money is usually forthcoming to support combat operations, and financial restrictions are not normally as much a factor. This is because a country is more willing to make sacrifices during a conflict than in a time of peace. Unfortunately, the financial restrictions imposed prior to a conflict have a definite affect on the military's ability to respond to a conflict.

Examples of financial restrictions are the number and type of aircraft a government buys for its forces. This also includes the number and type of weapons they buy, as well as the size of the force they fund. These are all effects of financial restrictions, which may limit or even dictate how an air force is going to fight a conflict.

The financial restrictions can also be indirect. An example of an indirect financial restriction facing the U.S. military today is the ability to support a major conflict or war in Europe in its early stages. To deploy all of the U.S. military forces to Europe on time in the event of a major conflict, the USAF needs a strategic lift capability of 66 million ton-miles per day. Currently the USAF only has a 44 million ton-miles per day strategic lift capability.[11] This will obviously limit some of the U.S.'s options at the start of any European style war. Trade-offs will have to be made on deploying the forces to Europe, while keeping the ones already there supplied. This will mean that the resupply of forces during the early stages will not be at a 100%, because of the need to deploy U.S. mainland forces to Europe as soon as possible. This inability to fully support the initial stages of a conflict of this magnitude could result in aircraft not having a full air-to-air weapons load for missions during this period, or even all of the aircraft deployed to the conflict. This will in turn affect what

options the USAF has in the type of aerial engagement they may be forced to fight.

The second restriction to aerial combat is the rules of engagement (ROE) under which aircraft fight. This is not a set of rules which is accepted by both sides in a conflict. Rather it is a set of rules that one side plays by regardless of what the other side does. In the Joint Chiefs of Staff publication number one, (JCS Pub 1), Department of Defense Dictionary of Military and Associated Terms, rules of engagement are defined as:

> Directives issued by competent military authority which delineate the circumstances and limitations under which United States forces will initiate and/or continue combat engagement with other forces encountered.[113]

An example of ROE in the Korean War was when U.S. forces were not allowed to cross north of the Yalu river. This gave the North Koreans a sanctuary from which they were able to regroup and rebuild their forces.[114] This particular example also shows how ROE may be political in nature. The United Nations imposed this restriction because they did not want to risk escalating the conflict into a war with China.[115]

A more recent example of how ROE can influence the air war was when two U.S. Navy F-14s shot down two Libyan Su-22s In peace time, the U.S. restricts its pilots to only shoot when a hostile act is observed. On August 19, 1981, one such act happened. Two F-14s from the carrier Nimitz were on patrol, during an exercise in the Gulf of Sidra off Libya,

when they started to intercept two Libyan aircraft flying toward the Nimitz. The intercepts were not unusual as thirty-five intercepts of Libyan jets occurred the preceding day, but all previous Libyan aircraft had either turned away or been escorted by the F-14s as they flew near the Nimitz. This intercept was different. One of the Libyan jets fired a heat-seeking missile head on at the lead F-14 from a range of about 1000 feet. The Libyan missile missed and the F-14s quickly out maneuvered the two Libyan jets, shooting them both down with U.S. heat-seeking missiles.[115]

Since the hostile act was not observed until very close range, all four aircraft involved in the incident were already in the aerial dogfight arena when the engagement started. This particular example shows how ROE, waiting for a hostile act, forced the U.S. aircraft into the aerial dogfight. Even though the U.S. F-14s carried AIM-7 Sparrow radar-guided missiles, they were unable to employ them beyond visual range (BVR), because of this restriction.[116]

As illustrated by these few examples, both financial restrictions and ROE can have a definite impact on the type of air war fought by a country. Chapter Three will show how financial restrictions encountered prior to the start of a conflict affected a country's air force's ability to respond to the conflict for the United States in Vietnam and the British in the Falklands War. Chapter Three will also show

how ROE forced aircraft into aerial dogfights in both Vietnam and the Israeli operation "Peace for Galilee."

FOG OF WAR

As Carl Von Clausewitz says in his book On War: "War is the realm of uncertainty; three quarters of the factors on which action in war is based are wrapped in a fog of greater or lesser uncertainty."[11] The uncertainty of war can be as simple as knowing that the enemy is out there, but not his numbers, to as complex as trying to figure out how to stop a surprise attack, where nothing about the attack, the enemy's strength or objective is known. This uncertainty of war is not limited to the unknown of the enemy, but also includes the friction that occurs in war.

In war this unseen friction is extremely hard to describe. This friction is in contact with chance everywhere and brings about effects that cannot be measured, because they are largely due to chance.[11] Friction represents the countless minor incidents that combine to lower the general level of performance, hindering the success of the intended goal. These minor incidents are those variables which one can never totally foresee or plan for completely. As Carl Von Clausewitz states in his book, On War, "Friction is the only concept that more or less corresponds to the factors that distinguish real war from war on paper."[11]

Someone who has never personally experienced an air war cannot fully understand all the friction involved. Once that someone has actually been in an air war, the difficulties became clearer. Yet, it is extremely hard to describe the unseen element which brings out this change of view.

An example to illustrate this element of uncertainty and friction is weather. Fog or haze can restrict visibility, denying visual acquisition of a threat until late or not at all, causing uncertainty about the threat and who will find who first, if at all. The uncertainty of how the weather will actually affect an air plan is not know until the mission is actually executed. Storms in the area may force a modification of the desired air plan of attack in the air at the last minute. This modification may not allow for all the variables as well as the original plan did, which will in turn create friction.

A second example of uncertainty and its associated friction is the speed in which events happen in the air. In today's air combat it is not unusual for aircraft to approach each other at speeds in excess of six hundred miles an hour (ten miles a minute). At these speeds, two aircraft twenty miles apart would have a closure rate of over twelve hundred miles an hour and meet in about one minute or less. If an enemy aircraft had a second enemy aircraft following ten miles in trail, then the friendly aircraft would have only thirty seconds until the second aircraft is upon him after passing

the first aircraft. If the friendly aircraft elects to stay and fight the first enemy aircraft, then he will have less than a minute to finish the aerial dogfight with him and then try to re-establish contact with the second enemy aircraft in order to engage him or deny him an unobserved entry on himself. The uncertainty of not knowing what the second enemy aircraft is doing, or if the second enemy aircraft even sees the friendly aircraft creates its own friction for the friendly aircraft's pilot just trying to figure out his own course of action.

Another example of the uncertainty and friction of time is with a formation of aircraft which has just been vectored on to an enemy formation. While engaging the enemy formation, the flight is informed of a new formation of enemy aircraft inbound only twenty miles away. This means the flight has less than a minute to finish their current engagements, regroup, acquire the inbound enemy flight, employ any kind of tactics, and engage the new threat.

These two examples of time are very simple examples because they do not take into account several other factors, which can work either for them or against them, such as weapons. Weapons can have a big impact on the uncertainty of time. Radar-guided missiles are but one example. If both sides are trying to employ radar-guided missiles at their maximum ranges toward each other, then at twenty miles both sides have already launched their missiles and are trying to

guide the missiles at each other while denying the other side the same ability. Just this one extra input presents an entirely new set of problems to the uncertainty and friction of time.

A third example of uncertainty is the enemy's plan. The enemy's plan represent his ability to counter one's plan. This uncertainty is dependent on many factors. Factors such as the capability of his equipment in relation to one's own equipment, the proficiency of his operators, the ability of his plan to take into account his weaknesses and strengths, and the amount of correct intelligence one has on the enemy. All these uncertainties create their own friction, which tend to hinder one's ability to handle a situation. To illustrate this better, a friendly aircraft tries to shoot an enemy aircraft at twenty miles with a radar-guided missile. The enemy aircraft is carrying electronic counter-measures to defeat the missile and does so. A second enemy aircraft is five miles behind the first with a radar-guided missile capability. This will put the friendly aircraft in range of the second enemy aircraft before he is in range to employ a heat-seeking missile or his gun on the first enemy aircraft. This denial of the radar-guided missile to the friendly aircraft creates a situation where the friendly aircraft is unable to employ his weapons optimally and may force him into another plan of attack which is not as advantageous as the first one.

These are but four examples of uncertainty and its associated friction. They can all happen together or independent of each other. It would take volumes to cover all the variables adequately that can apply to the uncertainty in war. This uncertainty and its associated friction in war is referred to as the "Fog of War" in this thesis. Chapter Three will show how the "Fog of War" puts aircraft into the aerial dogfight arena.

# CONCLUSION

Throughout the history of airpower man has tried to find ways to minimize and avoid the aerial dogfight. Unfortunately, he has been unable to achieve this for several reasons. Technology did not advance enough initially. As improvements in technology occurred, so did the ability of the enemy to devise effective countermeasures to negate these new technologies. Besides advances in technology, financial restrictions influenced the air war by limiting the resources available to fight. Still another factor limiting "fighting" options has been the introduction of highly restrictive rules of engagment. And finally, all those uncontrollable factors which create the friction of war, come together to form the "Fog of War." The impact of these uncontrollable factors, tends to disrupt the best laid plans and lead pilots into types of engagements which are not of their choosing, such as aerial dogfights.

In Chapter Three, four conflicts will be examined to see how technology, financial restrictions, ROE, and the "Fog of War" affected these conflicts and forced the aerial dogfight.

CHAPTER 1

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# CHAPTER 2

## RESEARCH METHODOLOGY

The research methodology used in this thesis examines numerous primary and secondary sources to determine the role of the aerial dogfight in today's air war. The aerial dogfight is primarily where aircraft continue to be engaged and destroyed by other aircraft. This thesis explores how both tangible and intangible factors influence where an aerial engagement occurs. The tangible factors discussed are: advances in technology, financial restrictions, and rules of engagement restrictions. The intangible factor addressed is known as the "Fog of War."

The primary sources used in the thesis consist of both government reports and first-hand accounts whenever possible. Secondary sources were used whenever primary sources were not available. The sources include published books, U.S. and British government publications and reports, U.S. Air Force reports, publications, periodicals, and unpublished papers. All of the sources used are unclassified.

Examples of primary sources used in this thesis include: Airpower in Three Wars, by General William W. Momyer who was the 7th Air Force Commander in Vietnam from July 1966 to August 1968; The Battle For The Skies Over North Vietnam which is part of the USAF's monograph series about Vietnam; and The Falklands Campaign: The Lessons, by the British Ministry of Defence about their experiences in the Falklands. For a complete examination of the sources used in this thesis, refer to both the review of literature in appendix 1 and the bibliography.

The search for information centered on documents available through the Combined Arms Research Library (CARL) at Fort Leavenworth, Kansas; the Defense Technical Information Center (DTIC); and both the Air University Research Library and the Air Force Historical Research Center at Maxwell AFB, Alabama. The research focused on the following subjects: aerial dogfights, air combat, air combat tactics, the Vietnam Air War, the Arab-Israeli Wars, the Yom Kippur War, the Israeli operation "Peace for Galilee," the Israeli Air Force (IAF), and the Falklands War.

Texts used by the U.S. Army Command and General Staff College were reviewed for applicable data. Theses written for the Master of Military Art and Science Program at Fort Leavenworth, Kansas were researched as well as papers written for both the Air War College and the Air Command and Staff

College at Maxwell AFB, Alabama. These theses and papers were useful for locating other pertinent sources.

Chapter One defines aerial dogfights, and provides a brief history of aerial dogfights. The chapter discusses advances in aviation technology, rules of engagement, financial restrictions and the "Fog of War."

The advances in aviation technology addressed in Chapter One are aircraft design, performance, and weaponry. These technologies are discussed from their initial stages to the present time. In particular, this chapter examines not only the advances on weaponry, but their limitations and counters. Chapter One defines rules of engagement (ROE) and explains how ROE restrictions affect the air-to-air arena. Chapter One also explains how financial restrictions encountered prior to a conflict limit the number and type of weapons and weapon systems available during a conflict.

In addition to the three tangible factors previously mentioned, Chapter One defines the uncertainty and friction that happens in war as the "Fog of War." The "Fog of War" is an intangible factor because of all of the variables that can cause it to happen. The chapter also gives some basic examples to help understand this important, but unquantifiable factor.

Chapter Three uses the basis built in Chapter One of the factors affecting air combat to analyze air-to-air effectiveness in four recent conflicts. The conflicts

examined in this chapter are the United States in Vietnam, the Israelis in both the 73' Yom Kippur War and their 82' Operation Peace for Galilee, and the British in the Falklands War. Four major factors have influenced these four conflicts in different ways. The four factors evaluated in Chapter Three are financial restrictions, technology, ROE, and the "Fog of War." The chapter examines each of the four conflicts in relation to these four factors.

Chapter Three shows how technology applied during the four conflicts was unable to prevent the aerial dogfight. This was due to technological limitations or restrictions imposed by one of the other three factors. ROE could influence whether a pilot would be forced into an aerial dogfight.

Financial restrictions are discussed in greater detail in Chapter Three, than in Chapter One. Financial restrictions influenced the equipment and tactics used in a potential engagement in three of the four conflicts. The final factor discussed in Chapter Three is the "Fog of War," which often caused pilots to find themselves in aerial dogfights.

In analyzing the four factors and how they affected aerial dogfights, Chapter Three looks at each of the four conflicts separately. Each conflict is examined in terms of the factors which attributed to causing aerial dogfights. This approach shows how the four factors have affected each of the four conflicts differently.

Chapter Four, the final chapter, presents conclusions drawn from the evidence. I will discuss where I feel the United States Air Force is in terms of training and being prepared to fight in the aerial dogfight arena today and also where we need to go for tomorrow.

Finally, the conclusions and recommendations in Chapter Four are based upon the evidence presented and my experience as a F-16 fighter pilot. My background is built upon exposure to flying in Central Europe, the Pacific region, and throughout the United States including Alaska. I have flown in almost every major large scale air-to-air exercise of the United States Air Force. This includes many joint and combined exercises as well. I have flown in the following exercises: ten Red/Green Flags in Nevada, two Maple Flags in Canada, two Cope Thunders in the Philippines, Team Spirit in Korea, and Brim Frost in Alaska. In addition, I have flown in several United States Air Force test and evaluation exercises dealing with the effective tactical employment of all aspect weaponry. I have also flown in support of numerous USAF Fighter Weapon School large scale force employment exercises.

Appendix 1 is a review of literature providing a brief description of the references used in this thesis.

Appendix 2 contains a "Glossary of Terms" as a quick reference for any unfamiliar terms.

# CHAPTER 3

## RECENT CONFLICTS

Since Vietnam, the aerial dogfight has been an important factor in the air war. Even though countries have tried through technology to eliminate this seemingly outdated form of air combat, the need for the aerial dogfight continues today. The importance of being able to fight effectively in the aerial dogfight has been demonstrated in four recent conflicts: the United States in Vietnam, the Israelis in the Yom Kippur War and Operation Peace for Galilee, and the British in the Falklands War.

In each of these conflicts, financial restrictions, technology, rules of engagement (ROE), and the "Fog of War" have had different degrees of influence on causing aerial dogfights. This chapter looks at each of these four conflicts and the impact each of these four factors had on causing aerial dogfights to happen in them.

## UNITED STATES - VIETNAM CONFLICT

The United States Air Force fought in Vietnam from 1965 to 1973 and learned many lessons about aerial combat. Financial restrictions encountered prior to Vietnam would affect the configuration of the U.S. aircraft used in Vietnam. The influence of technology, ROE, and the "Fog of War" would also contribute to U.S. aircraft engaging in aerial dogfights.

Financial restrictions encountered by the military prior to Vietnam had a definite effect on the type of aircraft the USAF had going into Vietnam. As with any period of peace, the period prior to the USAF's involvement in Vietnam in 1965 was no different. Budgets were tight in the Department of Defense (DOD) and the need to trim cost wherever possible, forced what proved in Vietnam to be some invalid assumptions. The priority in the Air Force prior to Vietnam had been in strategic bombers and then fighter-bombers capable of delivering nuclear weapons, not air superiority aircraft. Air superiority aircraft were envisioned as all-weather interceptors being used to stop incoming bombers either for fleet defense or for defense of the United States (Air Defense Command). The attempt to save money and cut costs where the USAF and DOD could, coupled with the development of guided air-to-air missiles produced a series of air defense fighters, the F-102, the F-106, and the F-4, with no guns and in which maneuverability was not as important as speed.[1]

The decision to not place guns on these all-weather interceptors was for three reasons. First, guns were not considered as effective an all-weather weapon as the guided missiles, even though the heat-seeking missiles did have problems with weather. Second, the gun was an aerial dogfight weapon and air warfare with the gun was considered outdated, because as stated in Chapter One, the aerial dogfight was no longer considered an efficient way to achieve air superiority and was losing its viability during this period.[1] These first two reasons lead to the third reason, money. Since the gun was no longer considered needed, it was not cost-effective to put a gun on these fighters.

Maneuverability, like the gun, was a cost effective decision.[1] Maneuverability was mainly important in the aerial dogfight, whereas speed allowed an aircraft to intercept an inbound aircraft faster. So, these all-weather interceptors were designed with speed as a requirement and priority over maneuverability. This factor of not having to design as for both speed and maneuverability equally, once again saved on the cost of the aircraft.

In making these cost-effectiveness decisions, the Secretary of Defense, Robert S. McNamara had the support of his assistant secretary of defense for systems analysis, Dr Alain C. Enthoven. Enthoven testifying to the Senate Subcommittee of the Committee on Armed Services and referring

to the decision to buy the F-4 with no internal gun for both the Navy and the Air Force said:

> I think, given the mission for which we envision our tactical fighters, and given our view of the total air battle, that we made a good choice with the F-4.[4]

As late as 1965, the priorities had not changed and Secretary of Defense McNamara had planned no change in the manned interceptor force as he called it, and in speaking before the House Appropriations Committee remarked:

> We believe that this force is appropriate for defense against what we presently foresee as a declining Soviet manned bomber threat. However, if the Soviets should deploy a new long-range bomber, which does not seem likely we would have to reevaluate the size and character of our interceptor force, and particularly the need for modernization.[5]

Abiding by this policy direction caused the USAF to enter the Vietnam conflict with air superiority aircraft which were not optimized for aerial dogfights. Vietnam showed the validity of the aerial dogfights as still a part of the air war. As the war progressed, it became clear the USAF needed air superiority aircraft with both more maneuverability and an internally mounted gun in order to gain the upper hand in the aerial dogfights.

Technology showed that radar-guided missiles, heat-seeking missiles, and the gun were all valid weapons in a conflict. The importance of a ground or airborne surveillance radar to effectively observe and help manage the air picture was also seen.

Radar-guided missiles accounted for 55 of the USAF's 137 confirmed air-to-air kills (both missile and gun kills) in the Vietnam conflict.[6] The radar-guided AIM-4 Falcon was responsible for five kills, with the radar-guided AIM-7 Sparrow responsible for the other fifty.[7] However, with these successes, the new technology of advanced missiles also showed some limitations.

| WEAPON | TOTAL KILLS | KILLS IN LAST NINE MONTHS OF WAR |
|---|---|---|
| Radar-guided missile | 55 | 23 |
| Heat-seeking missile* | 33 | 10 |
| Gun | 49 | 7 |
| TOTAL | 137 | 40 |

*Heat-seeking missiles had to be fired from the aerial dogfight arena. Even though it had longer range than the gun, the heat-seeking missiles range was only about two miles. Because of this range limitation, all of the heat-seeking missile kills were in the aerial dogfight arena.

One limitation was the kill rate of the radar-guided AIM-7 Sparrow, which was only a little over 11 percent.[8] Part of the problem was the initial radar-guided missiles were designed to stop bombers and did not have the maneuverability needed to hit a maneuvering fighter.[9] The radar-guided AIM-4 Falcon was designed for the U.S. Air Defense Command,[10] whose mission was to stop incoming strategic bombers.[11] The radar-guided AIM-7 Sparrow was not much different, being designed

initially for the Navy[12] for fleet defense against bombers.[13] Bombers have limited maneuverability compared to a fighter, which makes the bombers an easier target for fighters and the early missiles because extremes in position changes are not needed. During the last nine months of the Vietnam conflict the radar-guided AIM-7 Sparrow accounted for twenty-three of its fifty kills. This was due to both improvements in the F-4, the radar-guided AIM-7 Sparrow, and less restrictive ROE.[14] The improvements in the F-4, included an improved fire control system[15] and a more user friendly weapons control panel, simplifying both crew procedures and the complexity of setting up the gun and radar-guided AIM-7 Sparrow switches. The F-4 was also equipped with target identification system electro-optical (TISEO) equipment, essentially a binocular telescope in the left wing of the aircraft that greatly increased a pilot's visual acuity.[16] Improvements in the radar-guided AIM-7 included increased maneuverability, a larger warhead, and a proximity fuse. The proximity fuse caused the missile to explode if it passed near an aircraft, meaning that the missile did not have to actually hit the aircraft any more to explode.[17] The less restrictive ROE was the easing of the requirement to visual identify (VID) the aircraft prior to shooting at it. But to achieve these 23 kills, 216 Sparrows were fired.[18]

The heat-seeking AIM-9 Sidewinder proved its ability to down aircraft in a conflict by accounting for thirty-three

kills."[10] The heat-seeking AIM-9 Sidewinder did not have the range of the radar-guided missiles, only two miles, so it needed to be launched in the aerial dogfight arena. But the early heat-seeking AIM-9 Sidewinder suffered from one of the same problems as the radar-guided AIM-7 Sparrow, its lack of maneuverability against a maneuvering fighter target. It too had initially been designed to go against bombers."[11] The heat-seeking AIM-9 Sidewinder had a kill rate of 20 percent during the latter part of the 1965-1968 air campaign. This was better than the radar-guided AIM-7 Sparrow's kill rate, but still not a significant improvement."[12]

Even though the missiles had greater range, and the ability to be guided and maneuvered toward a target as advantages over the gun, the missiles were not designed for the close-in battle of a aerial dogfight between two fighter aircraft. The North Vietnamese pilots discovered they could successfully out-maneuver the U.S. air-to-air missiles and make it to the aerial dogfight arena to employ their own heat-seeking missiles and guns. As a result, U.S. F-4 pilots requested a gun be installed on their aircraft. The gun had two advantages in the close-in battle of the aerial dogfight over the missiles. Even though the gun did not have great range, only about half a mile, it had no minimum range from which it had to be fired, and the bullets fired from the gun could not be lured away by decoys such as flares, chaff, or electronic countermeasures. The only effective

countermeasures to the gun were range and maneuver. To effectively counter the gun with range meant to extend the distance between the two aircraft beyond the effective limits of the gun, but in doing so the defending aircraft would now expose himself to either a heat-seeking or radar-guided missile, depending on how great the range the defending aircraft was able to achieve. Then, if the attacking aircraft had missiles, he could fire a missile at the defending aircraft forcing him to maneuver to defeat the missile. This maneuvering by the defending aircraft would allow the attacking aircraft to fly back into gun range. So to defeat an attacking aircraft's gun by means of range was not as easy as it might seem if the attacking aircraft had both missiles and a gun. To defeat the gun through maneuver required more than just out maneuvering the bullets, but required out maneuvering the attacking aircraft as well. This was not always a case of who was in the most maneuverable aircraft won. If a skilled pilot was in a less maneuverable aircraft fighting against an inexperienced pilot in a more maneuverable aircraft, then the skilled pilot may still win if the inexperienced pilot did not know or was unable to optimumly maneuver his aircraft."[11] In May 1967, an externally mounted 20 millimeter (mm) gun pod on an F-4C was first used in combat."[11] Later in the conflict, in 1968, an F-4E was introduced with an internal 20mm gun."[11]

The gun proved it was still a valid weapon system in the air war by accounting for 49 of the USAF's 137 kills.[11] And in the last nine months of the conflict the gun had a kill rate of 50 percent, compared to 11 percent for the Sparrow, 10 percent for the Sidewinder, and 0 percent for the Falcon over the same period.[11] One reason for this high kill rate of the gun was technological improvements made to the F-4, once the need to able to dogfight was realized. The development of the stabilized lead computing gunsight for aiming with the gun in an air-to-air engagement and the internal gun on the F-4 in 1968,[11] as well as improved maneuverability and speed in the F-4 in 1972, yielded a much better platform from which to employ the gun.[11]

Even though the North Vietnamese had no air-to-air radar-guided missile[11], technology aided them through the use of ground based radar. The North Vietnamese had a highly sophisticated ground controlled radar network which covered their entire airspace.[11] They used this ground controlled radar network to vector their aircraft behind the U.S. aircraft strike formations so they could attack from a position of advantage.[11]

The USAF's ground controlled radar network covered very little of North Vietnam. This meant the USAF had to rely on its fighter aircraft's on board radar and that of the EC-121 for the air picture. The EC-121 was similar to today's E-3A Airborne Warning and Control System (AWACS). The EC-121

aided command and control, helped the F-4s run intercepts on Migs, issued Mig alerts to the strike packages, warned pilots of potential border violations, and issued surface-to-air missile (SAM) warnings. Unfortunately, these airborne radars had trouble detecting low-flying aircraft due to ground clutter."

In the Korean War, the USAF's kill rate went up dramatically when they set up a Tactical Air Direction Center (TADC) to provide complete radar coverage of the Mig bases along the Yalu. This coverage allowed the F-86s to be vectored to a position of advantage for their attack." In Vietnam, the U.S. was unable to do this because the North Vietnamese Migs seldom flew *into* South Vietnam or out of their own ground radar coverage," and the U.S. never occupied ground far enough north to set up a radar site to provide complete radar coverage of North Vietnam. The U.S. ground radar sites in South Vietnam and Thailand did not have the range to cover air operations above the nineteenth parallel, which was only about a hundred miles into North Vietnam."

Although, it should be noted that even if the U.S. had good radar coverage of North Vietnam, it would have been hard to totally surprise the North Vietnamese Migs in their own airspace. This was because the North Vietnamese had their own radar coverage, which was not the case of the North Koreans in the Korean War. The real effect of the U.S. having good radar coverage of North Vietnam would have been in

minimizing the surprise of the North Vietnamese Migs on the U.S. strike packages."

Along with the U.S. problem of radar coverage of North Vietnam, there were two Rules of Engagement (ROE) which had a definite impact on the number of aerial dogfights in Vietnam. These ROEs would sometimes result in the loss of any tactical advantage the USAF may have had prior to the engagement."

The first major ROE was a requirement to visually identify (VID) the enemy prior to attacking." This ROE was to minimize the chance of one of the U.S. aircraft shooting down another U.S. aircraft by mistake. Because of the small size of the enemy fighter aircraft, by the time a pilot was normally able to VID an enemy fighter aircraft, he was already in the aerial dogfight arena and within the minimum firing range of the radar-guided missile. This ROE reduced the number of opportunities for employing the Sparrow or Falcon radar-guided missiles. As General Momyer, Commander of 7th Air Force in Vietnam, pointed out in his book Air Power in Three Wars:

> Many kills were lost because of this restriction, particularly during periods of reduced visibility, or at times when so few of our fighters were in the area that almost anything on the radar was an enemy aircraft."

The VID restriction was eased during the 1972 air campaign (according to General Momyer, but no reason is given for why the restriction was eased). It can be speculated that

this ROE was eased for two reasons. First, the U.S. would lead the strike aircraft into the area with dedicated air superiority fighters. If these aircraft were the first aircraft in the area, this meant all other aircraft in front of these aircraft were probable enemy aircraft. Second, by this time improvements to the F-4 allowed for electronic identification of other aircraft outside of visual range."

The easing of this restriction came too late in the conflict to have a significant effect on the overall air-to-air exchange rate." The overall air-to-air exchange rate for the USAF prior to the 1972 air campaign was 2.19, and after it was 2.15." This meant, that for every USAF aircraft the North Vietnamese shot down, the USAF shot down 2.15 of theirs. It did, however, help the newer radar-guided AIM-7 Sparrow's numbers as twenty-three of its fifty kills came during this nine month period. Most of the older AIM-4 Falcons had been replaced with new versions AIM-7 by this time, as only five AIM-4s were even fired during this time with no accredited kills. Even though the kill rates for the AIM-7 Sparrow went up when the VID restriction was eased, the AIM-9 Sidewinder heat-seeking missiles achieved ten kills and the gun accounted for another seven kills in aerial dogfights accounting for seventeen of the forty aircraft kills achieved in air combat during this period. Thus, showing that the aerial dogfight was still very much a part of aerial combat."

The second ROE restriction did not permit U.S. aircraft hot pursuit of the enemy aircraft into China. This ROE was enforced to ensure China that our conflict was with North Vietnam and not China. The North Vietnamese took advantage of this sanctuary. If the U.S. fighters established a barrier patrol between the Migs and their base, the North Vietnamese would send their Migs into China if they did not like the situation, thus reducing their own attrition rates. This ROE reduced the possible number of air engagements when the U.S. would have enough of the air picture to permit beyond visual range (BVR) shots with their radar-guided missiles, because of the inability to go after the Migs when they would go into China. Even though this tactic saved North Vietnamese aircraft, it tended to give the U.S. local air superiority for their strike forces by default."

The "Fog of War" was to force aircraft into aerial dogfights during the Vietnam conflict. An example of this was on 29 June 196 , when four F-105s were flying a SAM (Surface to Air Missile) suppression mission and had just come off their target when they encountered four Mig-17s closing on them from behind. The F-105s had to quickly jettison their remaining ordnance and take evasive maneuvers. An aerial dogfight rapidly evolved with two of the F-105s hit by 23mm rounds from the Migs, and one Mig-17 shot down. Both F-105s were able to recover safely. This was also the first Mig kill by an F-105 in the Vietnam conflict." The encounter

demonstrates the uncertainty of war. The USAF knew the North Vietnamese had Migs. The USAF also knew what types of Migs and what types ordnance the Migs were capable of carrying. But the USAF F-105s did not know where or when the Migs would try to attack, if at all. The USAF F-105s did not know what type of Migs they would encounter, and how many Migs there would be, or what tactics the Migs would employ. In this particular example of the "Fog of War," these uncertainties plus the friction from just flying the basic mission allowed the Migs to show up unobserved behind the F-105s. This forced the F-105s into an aerial dogfight, causing them to jettison their ordnance on other than the planned target, while taking evasive actions in order to survive.

\s the uncertainties disappear, so does the "Fog of War." In the example above, if the F-105s had known that four Mig-17s were in their target area, the F-105s would of had their F-4 escorts seek out and engage the Migs prior to them entering the target area to prevent the F-105s from having to jettison their bombs on other than the intended target, and take evasive maneuvers to survive.

The Vietnam conflict showed that the U.S. had been wrong in the assumption that the aerial dogfight would be no more and the importance of aircraft maneuverability and an internal gun on an air superiority fighter. Of the USAF's 137 kills in the conflict, 82 of them had been in the aerial dogfight arena (33 with heat-seeking missiles and 49 with the

gun)." Financial constraints prior to Vietnam forced aircraft procurement decisions to be made on these wrong assumptions, forcing the USAF to initially enter Vietnam with air superiority aircraft ill fitted for the threat they faced and the mission they were given. Both technological limitations of radars and missiles, and ROE caused aircraft to end up in aerial dogfights. The "Fog of War" had an affect on aircrews finding themselves in aerial dogfights whether they wanted to be there or not. The Commander of the U.S. 7th Air Force in Vietnam, General Momyer, felt ROE was probably the most significant factor depressing the U.S.'s kill ratio.[47] Vietnam demonstrated that the advent of new technology does not always mean replace. Although the new missiles were unable to replace the need for a gun in fighter aircraft, they did show their value complementing each other. In summary, Vietnam showed that the aerial dogfight was still very much a part of aerial combat.

## ISRAEL - THE YOM KIPPUR WAR

On 6 October 1973, Yom Kippur Day - the Jewish Day of Atonement, the Syrians and the Egyptians simultaneously launched a surprise attack on Israel. The Syrian and Egyptian forces combined were equivalent in size to the total forces of NATO in Europe, and were put against Israeli's borders."

Financial limitations would have some impact on the type of air-to-air battles fought. Technology was not a big factor for the Israeli Air Force in minimizing aerial dogfights in the Yom Kippur War, and fortunately, ROE did not restrict the Israeli Air Force in the type of air war it was to fight during the Yom Kippur War. The "Fog of War" was an element of this war which found aircraft unintentionally having to engage in aerial dogfighting to survive.

Even though the Egyptians and the Syrians had the advantage of surprise at the start of the conflict, it did not help them very much in terms of the air war. By the end of the conflict, the Israelis had downed 162 Egyptian and 172 Syrian aircraft in aerial combat." The Israeli Air Force had lost only six aircraft in aerial combat and achieved a fifty-five to one kill ratio."

The only type of financial restriction in the conflict for Israel which affected the air war, was the pilots' uncertainty of how many Sparrows and Sidewinders the Israeli government was going to get from the United States. This was

due to the fact that the United States did not start resupplying the Israelis until after the Russians started resupplying both the Syrians and the Egyptians.[11] The United States resupply did not begin until October 14, 1973, nine days into the conflict and six days after the start of the Soviet resupply. The U.S resupply of Israeli was further hampered by North Atlantic Treaty Organization (NATO) countries and Spain refusing diplomatic clearance for USAF resupply aircraft. Only about 40 percent of the airlifted resupply material, which included aircraft parts and munitions, arrived before the cease-fire on October 24, 1973. Thirty-six F-4 and twenty A-4 fighter aircraft had been delivered, but this did not equal the Israeli's fighter loses of a hundred and three aircraft (only six in air-to-air combat).[11] Because of this concern, the Israeli pilots were conservative about using these missiles. They would use their gun instead of the expensive air-to-air missiles if they felt the missiles were not needed to achieve a kill.[11]

The Israelis had a slight technological advantage over the Egyptians and the Syrians in the air-to-air arena. The Israeli's primary fighter aircraft were 150 A-4 Skyhawks, 140 F-4 Phantoms, and 50 French Mirages. The only Israeli aircraft capable of carrying a BVR radar-guided missile at the time was the F-4 Phantom. The Egyptian's and Syrian's primary fighter aircraft were 270 Mig-21s, 60 Mig-19s, 320 Mig-17s, and 175 Su-7s. None of the Arab aircraft were capable of

carrying a radar-guided missile, but the total Egyptian and Syrian fighters out numbered the Israeli Air Force almost three to one."

Technology was never a big factor in preventing aerial dogfights in the Yom Kippur War, even though the Israeli Air Force had acquired radar-guided Sparrow missiles from the United States. The Sparrow accounted for only seven kills in the Yom Kippur War. The Israeli's achieved a 42 percent success rate with the Sparrow, which was higher than the U.S. had experienced in both training and combat firings of the missile." One reason the Israelis had so few radar-guided Sparrow kills in the Yom Kippur War was that a large portion of their fighters could not carry radar-guided missiles. The F-4 which could carry the radar-guided AIM-7 Sparrow, was used primarily as a bomber initially, because of the need to use every aircraft which could carry bombs to support their ground forces to slow the Egyptian and Syrian advance while the Israeli Defense Force (IDF) mobilized. This meant the Israeli's most prevalent type of engagement in the Yom Kippur War was still the aerial dogfight."

Heat-seeking missiles came into their own in the Yom Kippur War by downing close to two hundred aircraft in aerial dogfights. The Israeli Air Force used both U.S. made Sidewinders and their own Shafir II missiles."

The gun once again proved its validity by accounting for at least sixty of the Israeli Air Force's three hundred

and thirty-four kills. There were about seventy kills in which there were so many aircraft in the dogfights at once, that it was impossible to sort out which weapon had made the actual kill."

ROE was not a factor in the Yom Kippur War, because since the Israelis were fighting for their country's survival, they did not place restrictive ROE on the Israeli Air Force like the USAF encountered in Vietnam."

The "Fog of War" caused many pilots to find themselves in aerial dogfights unintentionally. One account of just such an incident happened to an Israeli flight of Phantoms attacking the Damascus city airport. As the flight went into the target area, missiles and anti-aircraft shells were firing at them. After they dropped their bombs and were trying to egress the target area, a flight of Migs dived down among them. As one of the pilots recalled:

> Everything is happening so fast! To the west I see a Phantom breaking left, with a Mig on its tail. I get behind them. If the Mig straightens its wings , I tell myself, I'll launch a missile at it.

The Mig rolls out and the Phantom pilot fired a Sidewinder at the Mig and hit the Mig. While waiting for the missile to hit its target, the Phantom pilot heard his back seater say to him: "Break, you son of a bitch! Break!" There was a Mig moving in behind him. Cannon fire then jolted his aircraft, but another Phantom chased the Mig away before it inflicted any more damage." This example of the "Fog of

War," demonstrates how the uncertainty of where and when the enemy aircraft will attack, plus the friction of how fast events can happen in an air war combine to produce the "Fog of War" and cause an unintended aerial dogfight.

While technological and financial limitations, as well as the "Fog of War," combined to cause most of the Israeli kills to be in aerial dogfights. The Yom Kippur War did show that even if ROE is not a factor, other influences made aerial dogfighting an inevitable part of the air war.

## ISRAEL - OPERATION PEACE FOR GALILEE

In June of 1982, following repeated PLO terrorist attacks across the Israel-Lebanon border and an assassination attempt on Israel's ambassador to the Court of St. James in London, the Israeli government decided to launch a military operation to clear the PLO out of at least a forty kilometer zone from Israel's northern border. This operation was called "Peace for Galilee." The PLO had, in May of 1982 alone, conducted twenty-six attacks on Northern Israel. On 4 June, the PLO directed a massive fire barrage at twenty-three Israeli towns and villages that lasted for two days. In this two day attack, the PLO fired six hundred Soviet Katyusha rockets alone, as well as 130mm and 152mm artillery rounds, killing, wounding, causing heavy damage, and forcing the civilian population along the Israel's northern border to live in bomb shelters.[1]

On 6 June 1982, operation "Peace for Galilee" began. The PLO, not the Syrians, were the intended enemy at the start of the operation, but the Syrians in Lebanon became part of the conflict when they entered fighting with the Israeli Defense Force (IDF) on 7 June. The Israelis then wanted both the PLO and Syrians out of southern Lebanon. It should be noted the Israelis never attacked Syrian forces or targets in Syria during the entire operation. This was due to the fact the Israel's war aim was not against the Syrians. Israel's

war aim was to create conditions which would prevent southern Lebanon from being used as a base for attack on Israeli territory. Initially, the plan was to push the PLO at least forty kilometers from the Israeli northern border, which was out of range of the PLO's rockets and artillery."

The Israelis, in executing operation "Peace for Galilee," showed no signs of financial restrictions in relation to the air war. Operation "Peace for Galilee" demonstrated how technology combined with sound tactics can have dramatic results. The Israelis in operation "Peace for Galilee" showed how ROE can play a definite role in creating an environment for the aerial dogfight. The "Fog of War" once again showed how aircraft can find themselves in the middle of an air battle.

The Israelis had a definite technological advantage in operation "Peace for Galilee." By 1982, the Israelis had developed one of the most advanced air forces in the world. They were flying the newest air superiority and multirole fighters, the F-15 and the F-16, both with thrust-to-weight ratios greater than one. This thrust-to-weight ratio means the thrust provided by these aircraft's engine(s) exceeds their loaded takeoff weight, allowing the aircraft better acceleration while maneuvering or climbing than the older Syrian aircraft. In addition to better acceleration and maneuverability at combat speeds, the F-15 and F-16 have superior radars and cockpit visibility that help in early

detection of enemy aircraft." The F-15 and F-16 are equipped with computer assisted aiming sights on their Heads-Up Display (HUD) which aid the pilot in the employment of his radar-guided and heat-seeking missiles as well as his gun. The computer assisted aiming in the HUD tells the pilot when he is in range and has achieved acceptable parameters to launch the respective missile he has called up or where to aim his aircraft to employ the aircraft's 20mm gun." The F-15 and F-16 also employ newer and improved missiles, such as the radar-guided AIM-7F Sparrow by the F-15, and the heat seeking AIM-9L Sidewinder by both the F-15 and F-16."

The Syrians were still flying primarily Mig-21s and export model Mig-23s as their air superiority fighters." The Mig-21 was developed in the late fifties and the Mig-23 in the late sixties. The Mig-21 and Mig-23 both have a thrust to weight ratio of less than one. Neither aircraft had computer assisted aiming similar to the F-15 and F-16, and the primary Syrian air-to-air weapons were the 1960s vintage AA-2 Atoll heat-seeking missile and the 23mm gun."

The Israelis also had a technological advantage in command, control, and communications (C3). The Israeli Air Force (IAF) used an airborne warning and control system (AWACS) aircraft, the Grumman E-2C Hawkeye, to vector their fighters against the Syrian aircraft and manage the overall air battle." The E-2C can monitor over two hundred aircraft simultaneously at ranges up to two hundred fifty miles." This

capability allowed the IAF to detect Syrian aircraft as they took off, and alert the IAF fighters to the inbound Syrian aircraft."[9]

While the IAF was able to enhance their C3 with the use of one E-2C, they worked hard to obstruct the Syrian's C3 using modified Boeing 707s. The aircraft were equipped with jammers to disrupt the Syrian radio and radar frequencies. By effectively jamming the Syrians communications and ground radar stations, the Syrian Migs were isolated and vulnerable to the IAF's AWACS directed F-15 and F-16 attacks."[10]

Besides technological advantages, tactics played an important factor to the Israeli success. The Israelis had learned from the Yom Kippur War the deadliness of the Syrian integrated air defenses. The Israelis worked hard and developed realistic tactics to negate the Soviet equipment."[11] The details of these tactics are still classified, as the Israelis believe their war against Soviet equipment is not over yet."[12] The Israeli results were overwhelming; seventeen out of nineteen SAM sites destroyed and twenty-nine Migs shot down in just one mission. By the end of the operation the Israeli Air Force had shot down eighty-six Syrian aircraft with no losses to air-to-air combat."[13]

The Israelis relied mainly on its F-15s and F-16s for air superiority. The F-16 accounted for forty-four kills in aerial dogfights, half of which were by the gun and the rest

by heat-seeking missiles. Once again demonstrating that the aerial dogfight was still valid in modern warfare."

Rules of engagement restricted where and when the Israeli Air Force could engage the Syrians. Three ROEs were responsible for setting up situations which minimized the Israeli's beyond visual range capabilities.

First, at the start of the operation on 6 June the Israelis were not authorized to attack the Syrians unless the Syrians attacked the Israelis first." The purpose of this ROE was an attempt to keep Syria out of Israel's quarrel with the PLO. The problem became complicated for Israel when PLO units withdrew behind the covering screen of Syrian forces and continued to fire into the eastern panhandle of Galilee." This particular ROE did not last very long. On 8 June, Israeli aircraft shot down six Syrian Migs in three separate air battles while supporting the Israeli Army and the air war with Syria began."

The second ROE the Israelis Air Force had to contend with was that they could not go after the Syrians in Syria, not even in hot pursuit." This meant they had to wait for the Syrians to come to them.

The last ROE effecting the type of air war fought, was when the Israeli Air Force went after the Syrian SAM sites in the Bekaa Valley. The Israeli pilots carrying bombs had strict orders: "First destroy the missile site, then take on the Syrian Migs."" This ROE meant that if there was a choice

of either engaging known inbound enemy aircraft or attacking the SAM site, the Israeli pilot had to attack the SAM site first, allowing the known enemy aircraft to get closer to the Israeli pilot, before the enemy aircraft would be engaged.

The Israeli ROEs which prohibited aerial engagements in Syria and directed the Israeli pilots to attack the SAM sites first, would set up what would be the largest aerial dogfight arena seen since World War II. This was because the SAM sites the Israelis attacked were near the Syrian border, allowing the Syrian Migs to get very close to the Israelis before they could engage the Syrians. Some two hundred jet fighter aircraft would be involved in the ensuring aerial dogfights. The friction caused by this many aircraft in one air battle would contribute to the "Fog of War."

Once again, as in the Yom Kippur War, the "Fog of War" placed aircraft in dogfights before they knew it. Syrian aircraft often launched in packs of as many as twelve aircraft which resembled an aerial phalanx. On June 9th, during the Israeli air attacks on the Syrian SAM sites in the Bekaa Valley, the Syrians launched multiple packs of jet fighter aircraft. This became the scene of one of the largest air battles ever fought, with some two hundred jet fighter aircraft involved. With this many aircraft in one air battle, it was impossible for the pilots to keep up with every aircraft and everything happening in the air battle. Aircraft while targeting and trying to fire at another aircraft, would

all of a sudden pass another aircraft that they did not realize was there. Once an aircraft entered an arena with this many aircraft, the pilots needed to spend most of their time looking outside of their aircraft, visually targeting, firing, and dodging each other, which allowed less time to look in the radar."[11] The results of this intense air battle were twenty-nine Syrian Migs shot down and no Israeli aircraft loses."[12] Although the uncertainty of war was not as big a player for the Israelis in this example, because the they had good intelligence, it was still there. The uncertainty of the size of the air battle which developed, and how to manage an air battle of this magnitude. The size of the air battle which did develop, created significant friction for the pilots flying in this air battle. The combination of the size of the air battle and the friction caused by this size combined to cause the "Fog of War," which contributed to Israeli aircraft entering into aerial dogfights.

For the Syrian pilots, the "Fog of War" was great. With their communications and radars being jammed by the Israelis, the Syrians knew very little about what they were about to fly into. This "Fog of War" for the Syrians was evident with their inability to cope with the Israelis plan, and not downing a single Israeli aircraft.

In operation "Peace for Galilee," the Israeli Air Force had brought together high motivation, quality tactics, and the best possible equipment to form an air force without

rival in the region."[1] The dramatic success demonstrated the Israelis were well prepared for the ensuing aerial dogfights. Operation "Peace for Galilee" showed how ROE and the "Fog of War" were the driving factors that forced many aerial dogfights to occur. Once again the aerial dogfight turned out to be an integral part of the air war.

## BRITAIN - THE FALKLANDS WAR

In April 1982, Argentine forces seized the Falkland Islands in an attempt to resolve a long-standing sovereignty claim to these British island territories in the South Atlantic. The Falklands are eight thousand miles from England, with no near by staging bases for the British to use. This forced the British into a primarily naval rescue operation of the islands."

The Falklands are only four hundred miles from the Argentine coast, but the islands have no airfield with a runway long enough to handle the Argentine fighter aircraft. The distance coupled with no suitable airfield for fighter aircraft operations and very limited air refueling assets, affected Argentina's ability to give the islands air cover and support with their fighter aircraft. The Argentine fighter aircraft did not have the fuel to loiter over the Falklands in any attempt to maintain air superiority." This factor did not affect the type of aerial engagements the Argentine aircraft had, but probably did affect the number of engagements they might have had due to the lack of loiter time. The Argentineans lost over a hundred aircraft in the Falklands War, but only thirty-one in air-to-air combat."

The Falklands War is an excellent example of how financial restrictions forced the British into fighting an aerial dogfighting type of air war. The technology the

British was able to bring down to the Falklands was limited partly by earlier financial restrictions.

Since the British were forced into an aerial dogfighting type of air war by financial restrictions, ROE and the "Fog of War" were not considered contributing factors to the type of air war which was fought. It should be noted that the "Fog of War" was present in the Falklands, but since the only type of air war for the British was the aerial dogfight, the "Fog of War" is only a factor in the number of aerial dogfights which occurred, and not a factor in the number of BVR engagements missed.

Prior to the Falklands War, the British government's defense polices had shifted toward the defense of NATO and nuclear deterrence and away from its colonial commitments due to economic reasons." In 1980-81, the British government acquired the Trident nuclear system to strengthen their nuclear deterrent force. Part of the shift away from their colonial commitments were significant cuts in areas of the military not directly related to NATO or homeland defense such as the Royal Navy's carriers, which would have a definite impact on how the British would be able to fight the air war."

The extent of these cuts were detailed in a June 1981 Defense White Paper. The majority of the reductions went to the Royal Navy. With the emphasis in the navy on the new Trident nuclear system and the antisubmarine warfare (ASW)

mission for NATO, the surface fleet would take most of the cuts."

Britain's only two carriers large enough to carry their F-4 Phantoms", the Eagle and the Ark Royal, would be scraped. The small carrier HMS Invincible was to be sold to Australia following the disposal of the two large carriers. Britain had also intended to dispose of its only two assault ships, the Fearless and the Intrepid."

With the Royal Navy's large carriers decommissioned, their Phantoms were transferred to the Royal Air Force." Now the navy no longer had an aircraft with a radar-guided missile capability, nor the capability to engage adversaries beyond visual range.

Even with these financial restrictions, the British still showed up at the Falklands with a technology advantage over the Argentineans. The British also made several modifications to their air assets, in preparation of the coming battle.

The Argentinean aircraft were armed primarily with heat-seeking AIM-9B Sidewinder missiles and guns." The British Harriers carried newer heat-seeking AIM-9L Sidewinder missiles and 30mm guns." The main difference being the newer AIM-9Ls.

The advantage of the newer AIM-9L over the AIM-9B was that the attacking British aircraft did not have to maneuver behind the Argentinean aircraft for the missile to see the hot

exhaust of its target. This meant the missile could be launched from almost any aspect at its target. The results speak for themselves; the AIM-9L was accredited with destroying twenty-four aircraft of the British's thirty-one confirmed air-to-air kills." The AIM-9L missile proved it was a more reliable missile than the AIM-9B. The British fired twenty-seven AIM-9Ls, with twenty-four observed hits." Even though the British heat-seeking missiles were better than the Argentinean's heat-seeking missiles, they were still only dogfight missiles. The Harriers still possessed no beyond visual range (BVR) capability to shot down an enemy aircraft.

The Argentinean Mirages carried Matra R.530 radar-guided missiles, but there were only two known launches against the Harriers. By British accounts, on both occasions the Argentinean pilots for unknown reasons broke away rather than continuing to illuminate their targets so the missiles could hit their targets."

The Harriers were equipped with radar warning receivers (RHAW), chaff dispensers and IR decoys (flares)." The ground attack version of the Harrier (GR3) had to be modified to carry the heat-seeking AIM-9 Sidewinder missile and an improved inertial navigation system (INS) for over water operations and alignment on a moving deck." A few of their Nimrod aircraft were also modified to carry the Sidewinders or Harpoon missiles. Six Vulcan bombers were converted to air refueling tankers."

Even though financial restrictions forced the British into the aerial dogfight, advanced weaponry in the form of the AIM-9L paid off. Unfortunately, this advanced weaponry was for use in the aerial dogfight, and not BVR. The score in the aerial dogfight arena by the end of the conflict was thirty-one to zero in favor of the British.[101] The Falklands War demonstrated that it does not take a combination of outside influences to force aircraft into aerial dogfights, but only one. In this case financial restrictions in the form of constraints made prior to the conflict affected how the conflict was fought. The Falklands War also showed that a country does not always have the time to correct all the deficiencies caused by financial constraints during the peaceful years. The Falklands War demonstrated that the aerial dogfight was a valid part of the air war and how a restriction, if severe enough, can make it the only option in the air war.

## Summary

The aerial dogfight was unavoidable in all of the conflicts discussed in this chapter. The conflicts varied from Vietnam seeing the early attempts at using new technology to eliminate the need for aerial dogfights, through the Israeli Yom Kippur War, the British Falklands War, to the Israeli operation "Peace for Galilee," where the most advanced technology available was employed. As Lieutenant General Kelly H. Burke, USAF, Retired, quoted an unnamed British defense expert who was very proud of Britain's successes in the Falklands War: "We fought yesterday's war in the Falklands. The Israelis fought tomorrow's war in Lebanon."[11] The four factors of financial restrictions, technological restrictions, ROE, and the "Fog of War" were examined against each of the four conflicts to determine the amount of influence each of the factors contributed to causing aerial dogfights. The amount of influence of the factors varied for every conflict from very little or no influence to the soul cause of aerial dogfights in a conflict. But the bottom line in each of these conflicts was that the aerial dogfight was a valid part of the air war.

In Vietnam, technological limitations, ROE, and the "Fog of War" were the main causes for aerial dogfights. Vietnam also demonstrated how assumptions made about the employment and effectiveness of a non-combat tested new

technology combined with financial restrictions made prior to a conflict affected a country's ability to fight initially. Vietnam showed that all four of the factors examined contributed to causing aerial dogfights. The validity of the aerial dogfight as an integral part of the air war was reestablished in the Vietnam conflict.

In the Yom Kippur War, financial restrictions, technological limitations, and the "Fog of War" were the causes of aerial dogfights. The Yom Kippur War showed that it did not need all four of the factors examined to cause aerial dogfights, as ROE was not a factor at all during this conflict. The Yom Kippur War did demonstrate once again that the aerial dogfight was a valid part of aerial combat.

In the Israeli operation "Peace for Galilee," ROE and the "Fog of War" were the major contributors causing aerial dogfights. This operation showed that even if financial restrictions were not a limiting factor, aerial dogfights still occurred. The combination of advanced technology and sound tactics demonstrated how valuable they can be in the air war, with the Israelis obtaining an unprecedented eighty-six to zero kill ratio. Operation "Peace for Galilee" illustrated that even with most advanced technology properly employed and no financial restrictions to speak of, the aerial dogfight is still unavoidable in the air war, in this case, because of ROE and the "Fog of War."

Finally, in the British Falklands War, financial restrictions alone forced the British into the aerial dogfight arena. But once again, advanced technology, even though limited, proved their worth as in operation "Peace for Galilee," helping the British achieve a thirty-one to zero kill ratio in the air-to-air arena. The Falklands War showed how it only takes one of the factors examined to force the aerial dogfight into the air war, thus demonstrating the validity of the aerial dogfight in aerial combat.

In each of these conflicts the aerial dogfight could not be avoided for different reasons. Each of these conflicts demonstrated that the aerial dogfight was very much a valid part of the air war.

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# CHAPTER 4

## CONCLUSIONS AND RECOMMENDATIONS

The data in the previous chapters demonstrate how the aerial dogfight is an inescapable part of air combat. The thesis examined technology and its inability to keep aerial dogfights from happening. The thesis looked at four recent conflicts showing that technology, financial restrictions, ROE, and the "Fog of War" can influence the air war to the point where the aerial dogfight is inevitable. The amount of influence each of these factors had on the air war of the different conflicts varied, but the sum total of their influence in all cases set up an environment where the aerial dogfight could not be avoided.

Technology has tried to eliminate the need to be able to dogfight by designing weapons and weapon systems which can not only find enemy aircraft beyond visual range of the human eye, but can also engage the opposing aircraft before it enters the aerial dogfight arena. Unfortunately, these technologies have limitations. The limitations change as

technology improves each system, but limitations always exist. As one side of an air war tries to employ a new technology to its advantage, the other side tries to minimize or negate the new technology by taking advantage of its limitations.

An example of this cat and mouse game with technology has been with the advent of radar and the radar-guided missile. Radar was developed to give the pilot the ability to cover more area quicker than was possible with the human eye. The initial radars were ground radars because they were too large to be mounted on aircraft. The counter to this technology was the development of chaff. Since the ground radars were at stationary sites, once it was known where they were located, the chaff could be used effectively against them. By this time radars had been mounted on aircraft because even though the ground radars could vector friendly aircraft near the enemy aircraft, if it was night the pilot still could not see his target to shoot at it, so he needed his own on-board radar to find the target he was being vectored toward. The early airborne radars gave their pilots another advantage in that they were not stationary, so the enemy did not know where the airborne radars were to effectively employ chaff against it. The radar-guided missile was then developed to complement the airborne radar, giving the pilot a means of not only seeing his enemy beyond visual range but also killing him beyond visual range. The early radar-guided missiles were not very maneuverable because they

were initially designed to stop bombers. The counter to this limitation was for the fighters to out maneuver the missile. Radar warning receivers were developed to help warn pilots of radars which could see them. This development not only helped the pilots know when to maneuver their aircraft, but also helped them to timely employment of their chaff. Technology improved the maneuverability of the missiles, but they were still vulnerable to chaff. Another counter which came along to negate the radar and its guided missiles was using electronic signals to jam or deceive the radar. This denied the radar the information it needed to employ its radar-guided missiles against an enemy aircraft. Technology has now developed jam resistant radars and missiles. The counter to this has been the development of low observable or stealth technology which denies the radar the ability to see its intended target. If the radar can not see its target, it can not employ any missiles against it.

The battle over technology developing a better weapon and then developing a counter to it, is and will be a never ending struggle. The struggle of technology, counter technology, counter-counter technology denies either side of a conflict from employing a weapon system to its maximum potential. The other factors of financial restrictions, ROE, and the "Fog of War," addressed in previous chapters also hinder the ability of one side to employ their weapons systems to their full potential.

ROE has been and probably will continue to be a limiting factor in the type of air wars which are fought. ROE has been normally a combination of both political and safety restrictions. For political reasons governments have always imposed restrictions on their military forces. These political restrictions can and have affected a military's ability to employ all of its resources and technologies as the military might have otherwise liked. Political restrictions in ROE for example, have limited aircraft from crossing political borders to engage early or pursue enemy aircraft. Political restrictions have denied aircraft not only in time of conflict, but in peace time the ability to employ radar guided missiles BVR, having to wait until fired upon, thus putting them in the a close in dogfight from the start. Safety considerations have caused limiting ROE, which have limited when aircraft are allowed to employ their radar guided missiles BVR, trying to minimize the chance of aircraft on the same side from shooting each other down. Whether the ROE has come for political or safety reasons, it must be noted that they will be a part of any conflict fought today or tomorrow, although the degree to which they limit the military actions will vary.

Today as in the past, financial restrictions are going to have an impact on the type of air war a country can afford to fight. Financial restrictions are more evident prior to a conflict when a country is at a time of peace, than when a

country is engaged in a conflict. This is because a country engaged in a conflict will normally make sacrifices to aid its military. These financial restrictions made prior to a conflict can limited the number and type of advanced weapon systems a country has to employ, or can employ. It can also affect a prolonged air war, when a country starts to use its resources and is unable replenish them. This will have a definite effect on the tactics a country can use in a conflict.

The ever changing conditions of the air war results from the uncertainty and friction which occurs between all the variables in the air war to achieve a situation known as the "Fog of War." Just a few examples of these variables are the number and type of aircraft airborne in the area, the number and type of weapons that each aircraft is carrying, the amount of deception tactics employed (to include chaff and ECM), and the amount of intelligence one side has on the other side's limitations or weaknesses.

The four factors were examined against each of four conflicts separately. The four conflicts were the United States in Vietnam from 1965 to 1973, the Israeli's Yom Kippur War in 1973, the Israeli's operation "Peace for Galilee" in 1982, and England in the Falklands War.

In the Vietnam conflict, the two factors that stood out, which contributed most to causing aerial dogfights were limitations in technology, and ROE. Financial restrictions

encountered by the tactical air forces prior to Vietnam forced the USAF to initially have no air superiority aircraft designed with the aerial dogfight in mind. The "Fog of War," as always, took its toll causing several dogfights to take place which were unplanned.

Vietnam was the first conflict in which BVR radar-guided missiles were employed. The limitations of the early radar-guided missiles and their radars proved technology had not really replaced the aerial dogfight. The early radar-guided missiles lacked the maneuverability needed to engage fighters and their radars had trouble finding aircraft below them or staying locked to maneuvering targets. The early missiles also had reliability problems, causing the USAF to tell its aircrews to fire two missiles at each target. The Vietnam conflict did show that radar-guided and heat-seeking missiles were not replacements for the gun in fighter aircraft, but instead complemented the gun. This complement of weapons now gave air superiority aircraft a long, medium, and short range capability to engage enemy aircraft with the radar-guided missile, the heat-seeking missile, and the gun.

ROE in Vietnam limited the chances the U.S. aircrews had to employ their BVR radar-guided missiles. The U.S. ROE for most of the Vietnam conflict had strict BVR rules, which required visual identification of the target/enemy aircraft before being cleared to shoot at it. This ROE denied the U.S.

aircrews a chance of a shot BVR, normally forcing them into the aerial dogfight arena to achieve their kill.

The financial restrictions encountered by the tactical air forces were not so much as during Vietnam, but actually prior to Vietnam. These restrictions were due to budget constraints which forced the tactical air forces to evaluate every requirement of new aircraft and drove to the deletion of the gun from their air interceptor aircraft. As the gun was not considered necessary any more with the advent of guided missiles and nuclear weapons. These two technological advances, guided missiles and nuclear weapons, also led many to believe the aerial dogfight was no longer a valid part of air war. These financial restrictions caused the USAF to begin the Vietnam air war with out a fighter aircraft which was prepared to fight in an aerial dogfight.

The "Fog of War" in the Vietnam conflict played an important part of air war, causing aircrews to find themselves in dogfights with the enemy whether they wanted to be there or not. This is because of all the variables in which the aircrews may encounter, but have no control over in an air war.

In 1973, the Israelis were attacked by both Egypt and Syria in what has become known as the Yom Kippur War. The Yom Kippur War was influenced differently by the four factors examined than the Vietnam conflict. The main factors causing aerial dogfights in the Yom Kippur War were technology,

financial restrictions, and the "Fog of War." ROE was not a limiting factor for the IAF in the Yom Kippur War, unlike the U.S. in Vietnam.

Technology in the Yom Kippur War was limited. The Israelis had radar-guided missiles, but the only aircraft that could carry it, the F-4 Phantom, was used primarily in the air-to-ground role. This lack of quantity, limited the number of BVR engagements possible, and forced the majority of the engagements into the aerial dogfight arena.

The lack of BVR weapons was due primarily to financial restrictions. The concern over the Israelis ability to get more missiles in time, and if so, how many more missiles, caused many IAF pilots to use their aircraft's gun instead of a missile, if they felt they did not need to use the missile to get their kill.

Even though many pilots had to press into the dogfight to achieve their kills, many more pilots found themselves in dogfights due to the "Fog of War." As in Vietnam, the "Fog of War" caused several unplanned dogfights.

ROE was not a factor in the air war for the IAF in the Yom Kippur War. Since Israeli was fighting for her survival in this war, the Israeli government placed no political restrictions on the IAF. Likewise the IAF placed no ROE on itself which limited its ability to respond to the all out war it found itself in.

In operation "Peace for Galilee" in 1982, the Israelis found themselves in another air war. The Israelis were affected by the four factors differently than they were in the Yom Kippur War. ROE and the "Fog of War" were the major factors contributing to the Israelis finding themselves in aerial dogfights. Technology for the first time was not a limiting factor, as well as financial restrictions did not play an important part in this conflict.

ROE in operation "Peace for Galilee," force many of the Israeli fighters into aerial dogfights. Since Israel was not fighting for her life as in the Yom Kippur War, the government of Israel placed two key ROE on its forces for political reasons. The IAF further placed a third key ROE on itself ensuring the pilots understood the IAF's priority of target destruction. The Israeli ROE in operation "Peace for Galilee" demonstrated how even without technological and financial restrictions, ROE alone can cause aircraft to become engaged in aerial dogfights.

Besides ROE, the "Fog of War" as in the two previous conflicts caused aircraft to find themselves involved in aerial dogfights. Operation "Peace for Galilee" was the seen of the largest jet fighter air battle ever fought, with some two hundred jet fighter aircraft involved in just one battle.

As financial restrictions were not a major factor for the Israelis in operation "Peace for Galilee," they were the opposite for the British in the Falklands War. Financial

restrictions from government military reductions that had gone on for years prior to the Falklands War were the main reason the British were not able to take any of their F-4 Phantom aircraft with them to the Falklands. The F-4 Phantom was their only aircraft at the time with a BVR capability. Without the F-4 Phantom, the British were forced to fight an aerial dogfight type of air war.

Since the British were forced into an aerial dogfight type of air war by financial restrictions, ROE and the "Fog of War" were not considered factors causing aerial dogfights. It should be noted that the "Fog of War" was present in the Falklands, but since the only type of air combat for the British was the aerial dogfight, it is only a factor in the number of aerial dogfights which occurred, and not a factor in the number of BVR engagements missed.

Technology was also not a factor causing aerial dogfights in the Falklands War, because of the financial restrictions limiting the technology the British were able to bring with them. But technology is worth mentioning and was an important factor to the British success in the air war. The British had a technological advantage in the aerial dogfight over the Argentineans. They had a superior dogfight missile with the heat-seeking AIM-9L sidewinder and an aircraft with some unusual fight characteristics in the Harrier. This proved the value of modern technology. The British were able to boast a thirty-one to zero kill ratio.

In each of the four conflicts examined, different factors forced aircraft into aerial dogfights. In some of the conflicts there were multiple factors forcing aircraft into aerial dogfights, or as in the Falklands there was only one. This is not to say that if the one overriding factor in the Falklands had not been present, the other factors would not have individually or combined to cause aerial dogfights too. But it does show how just one factor by itself can drive an entire air war by eliminating all other options.

Throughout all of these conflicts technology made improvements from those seen in the Vietnam conflict. The maneuverability of the missiles both radar-guided and heat-seeking has improved significantly. The guidance of both of these missiles have improved, making them harder to fool with maneuvers or counter-measures. The reliability of the missiles have improved with each conflict. The aircraft radars have also improved over the years. But so has the counters to all of these improvements.

ROE is a factor which is hard to plan for, because of its nature. ROE can be politically motivated and depending on the governments motivation, will vary in each situation. ROE can be militarily motivated as well, for safety reasons to deconflict aircraft, or prioritize actions for example. As shown ROE affected each conflict differently, and will probably continue to do so in the future conflicts.

Financial restrictions are dangerous restrictions which governments tend to walk a fine line on. A real lesson can be learned about financial restrictions from the Falklands War. In trying to save money by cutting from the defense budget, the British government lost a very important capability forcing it to fight an aerial dogfight type of air war as their only option. The British were lucky, because the Argentines had not equipped their air forces correctly either for the long range type of air war it had to fight. With the recent events in Europe and the United States trying to balance the budget, the United States Government needs to be careful about what it cuts out of its defense budget so that it does not get got off guard like the British did in the Falklands.

The "Fog of War" is a factor that was in all four conflicts examined and will be in all future conflicts of any size by its nature. The effect of the "Fog of War" can not be eliminated, but its potential damage to the air war can only be minimized through the realization that it will be there and effectively planning for it. The "Fog of War" has caused and will continue to cause aircraft to find themselves in aerial dogfights.

In all four of the conflicts examined the aerial dogfight proved to be an unavoidable part of the air war. The factors causing the aerial dogfights differed in the amount of influence they had in every conflict.

An important lesson from these conflicts, was in the use of technology. Through technology, the U.S. in Vietnam, thought it had eliminated the need for guns in their air-to-air fighters because of the longer kill ranges of the guided missiles. This philosophy had a weakness in it. As the Japanese warrior Musashi wrote in 1645 in his book, A Book of Five Rings:

> Some schools have a liking for extra-long swords. From the point of view of my strategy these must be seen as weak schools. This is because they do not appreciate the principle of cutting the enemy by any means. Their preference is for the extra-long sword and relying on the virtue of its length, they think to defeat the enemy from a distance.[1]

While the U.S wanted to defeat the enemy from a distance, they forgot about the principle of defeating the enemy by any means. Musashi then goes on to say:

> I expect there is a case for the school in question liking extra-long swords as part of its doctrine, but if we compare this with real life it is unreasonable. Surely we need not necessarily be defeated if we are using a short sword, and have no long sword?
>
> It is difficult for these people to cut the enemy when at close quarters because of the length of the long sword. The blade path is large so the long sword is an encumbrance, and they are at a disadvantage compared to the man armed with a short companion sword.
>
> From olden times it has been said: "Great and small go together."[2]

As learned from Vietnam the longer range missiles actually complement the shorter range gun, but do not replace it.

The Israelis showed this point in 1973, with the Yom Kippur War, and in 1982, when they executed their operation "Peace for Galilee." In both of these conflicts the Israelis used radar-guided, heat-seeking, and the gun to shot down their opponents.

Even the British, in the Falklands demonstrated this point of complementing weapons. Without any radar-guided missiles, the British still used both heat-seeking missiles and the gun effectively against the Argentineans.

The bottom line is that the aerial dogfight is and will continue to be unavoidable in today's and tomorrow's air war. The reasons the aerial dogfight is and will remain unavoidable, vary with every conflict. The need to prepared properly for the aerial dogfight is imperative. The success one side achieves in the aerial dogfight, will play an important part in helping that side achieve air superiority in the air war.

## AREA FOR FURTHER STUDY

Training is an important aspect which deserves examination. Training should be looked at in respect as to how well an air force does in an aerial dogfight, not as to whether it caused an aerial dogfight. Training was not addressed in this study for two reasons. First, was due to the classification of the thesis. The Israelis Air Force's training is currently classified, as the Israelis believe they are not done fighting yet. Second, unless one side of a conflict alters its training during the conflict and the conflict is long enough in duration to see a comparison of the results of the changes in training, both sides of the conflicts training then needs to be examined. Since three of the conflicts examined were of relatively short duration, this second factor tends to come right back to the first one of classification. What specifics one country knows about another country's military, to include training, is generally classified.

Of the four conflicts addressed in this thesis, Vietnam is the only one which can be addressed under these conditions. In Vietnam, the United States Navy changed its air combat training habits during the conflict and the conflict was of sufficient length to compare the results. And to add to the validity of the comparison, the USAF did not change its air combat training until too late in the conflict.

This allows for a fair comparison without having to know the specifics of the North Vietnamese air combat training.

Vietnam is a good example of how important training is to the outcome of aerial dogfights. Prior to Vietnam, the United States had shifted its training toward the new guided missiles and nuclear weapons. Aerial combat was almost totally eliminated. During the late fifties and early sixties no requirement existed for even one Air Combat Maneuvering (ACM) training sortie (flight) in most operational tactical fighter units.[1] For safety reasons, Dissimilar Air Combat Training (DACT) was considered dangerous and in May 1968 a TAC supplement to AF Manual 51-34 prohibited any DACT.[4] By 1969, Air Combat Training (ACT) in TAC was virtually no more.[5]

Vietnam showed the importance of training in the aerial dogfight. Of the few aces the U.S. had in Vietnam, eighty percent of their kills occurred in maneuvering combat.[6] Even the fighter-bombers showed a need to be able to do basic dogfighting. The F-105 accounted for twenty-seven Mig kills, twenty-five of them credited to the gun.[7]

Through 1968, the U.S. Navy's kill ratio was only 2.4 to 1. In mid-1968, a special U.S. Navy study group headed by Captain Frank W. Ault analyzed every U.S. Navy aerial engagement in Southeast Asia. The Ault Group concluded that the Navy needed to train aircrews better for aerial combat. The Navy founded the TOPGUN Fighter Weapons School in late 1968 and began an aggressive DACT program. Following the

creation of TOPGUN, the Navy shot down twenty-five Migs while losing only two aircraft in aerial combat to Migs in the rest of the Vietnam conflict, for a kill ratio of 12.5 to 1.[9]

The USAF was not as quick to realize the necessity for realistic air-to-air training. In November 1971, the USAF Fighter Weapons School hosted a joint command and service working conference on ACT training concepts. Out of the conference in August of 1972, the USAF Fighter Weapons School taught an ACM course for Southeast Asia bound aircrews just out of F-4 upgrade training. By the end of 1972, TAC started to revive its ACT program that had almost totally died by 1969. While the efforts produced post-war training programs, it came to late for the USAF to have a significant effect on the USAF's kill ratio in Vietnam, as the air war ended in January 1973.[10]

The United States learned in Vietnam the importance in training, and the Israelis echo that feeling. The Israelis place considerable priority on training, maintaining that technology is useless without the ability to successfully employ it. Although the Israeli training is classified, the Chief of Staff of the Israeli Defense Force (IDF), Lieutenant General Rafael Eitan states: "Training is of greater importance and significance than the means of warfare, the weaponry systems, and the technology."[11]

CHAPTER 4

ENDNOTES

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4. Ibid., 55.

5. Branford J. McAllister, Major, USAF, "Air-to-Air Continuation Training in the Tactical Air Command," (Maxwell AFB, Alabama: Air Command and Staff College, Air University, 1985), 18.

6. Barrett Tillman, "The Fighter Pilot: Myth vs Reality," USAF Fighter Weapons Review, Issue 1, Volume 37 (Spring 1989): 8.

7. Frank R. Futrell, et al., Aces and Aerial Victories, The United States Air Force in Southeast Asia 1965-1973, (Office of Air Force History Headquarters USAF, 1976), 157.

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9. McAllister, "Air-to-Air Continuation Training in the Tactical Air Command," 18-19.

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APPENDIX 1

## APPENDIX 1

## REVIEW OF LITERATURE

The appendix reviews the research literature upon which the study is based. The references discussed are organized in following order: books, government publications, periodicals, and unpublished papers. The relevance to the thesis is described for each item listed.

The research began with a quest to locate everything written about the history of aerial dogfighting and the four conflicts examined in the thesis. Classified, declassified and unclassified sources were reviewed. The review showed that it was not unusual for much of the classified data to not agree and that the unclassified data was very close or the same as the classified.

This study is based on sources which differ by type and date of publication. Almost all of the references listed in the bibliography have historical facts about the evolution of either air combat or technology. Primary sources were used

when available over secondary sources.

The books used fell into four categories: historical facts about the evolution of air combat; historical facts about aircraft and weapon technology; historical facts about the conflicts examined; and current facts about today's technology. The date of publication of the books used varied widely because of the wide variety of books used.

Government documents were used to the maximum extent possible when available. Government documents by the actual individuals involved vice a sanctioned government report were used first if both were available. The USAF has an amazing amount of information still classified, even about the Vietnam conflict.

The periodicals used were almost entirely professional military journals. This was done intentionally to minimize the inaccuracies and sensationalism which happens in non-professional journals. Most of the periodicals used were written within the first few years after the conflicts examined.

The majority of the unpublished papers used, turned out to have a wealth of other sources in each of their respective bibliographies. This was extremely helpful in the search for information, facts, and primary sources.

BOOKS

The Arab-Israeli Wars (403 pages) by Chaim Herzog tells the story of Israeli's fight since 1947 to preserve her existence against the repeated attacks of neighboring Arab nations. Herzog appears to lack objectivity with some of his criticism of Israeli leaders, but the story and details of the fighting is what makes this book useful to the thesis.

Dictionary of Guided Missiles and Space Flight defines and explains the most commonly used terms in the guided missile and space flight fields back in 1960. This dictionary was an invaluable source to the thesis for describing the early air-to-air missiles.

Falklands, The Air War (480 pages) by Rodney A. Burden and others, is an account of the air battle fought by both Argentina and the United Kingdom during 1982. It is presented in a style which provides a balanced summary of the activities of every flying unit involved and which records their achievements against a common measure.

Fighter Pilot Tactics; The Techniques of daylight Air Combat (176 pages) by Mike Spick, is an excellent source of historical data on aerial tactics. It covers the period from before the first dogfights through the early conflicts of the 1980s. It also does a good job of trying to explain what they were trying to achieve with each new tactic. This book was

useful to the thesis for its historical analysis of early tactics.

The Fighting Israeli Air Force (208 pages) by Brigadiar General Stanley M. Ulanoff, USAR, and Lieutenant Colonel David Eshel, IDF (Retired), chronicles the IAF from their beginnings in Messerschmitts to today's F-15 Eagles and F-16 Falcons. Accounts by pilots, strategists, and officials of the IAF made this book very helpful to the thesis.

History of the U.S. Air Force by David A. Anderton chronicles the events of the U.S. Air Force from its earliest days as a balloon unit during the Civil War to its current foothold on the doorstep of space. An interesting book, but generally did not have the level of detail desired and served only as a starting place for some of the research.

An Illustrated Guide to Modern Fighters and Attack Aircraft (159 pages) by Bill Gunston is an illustrated directory of the worlds current fighters and attack aircraft. This book was useful for its technical data about aircraft and their weapons.

Illustrated Guide to U.S. Missiles and Rockets by Stanley M. Ulanoff gives facts on U.S. missiles and rockets of the fifties and early sixties. The book was useful to the thesis because it discusses the missile's history, its intended mission, and its electronic guidance.

Introduction to Airborne Radar (621 pages) by George W. Stimson, is a technical book which explains the basic

principles of aircraft radars and their history. This book was useful to the thesis for its technical data about radars, radar cross sections, and radar guided missiles.

Jet Fighters (157 pages) by Micheal Taylor gives a historical perspective of jet fighters from their inception to today. This book was valuable for both its historical and technical about jet aircraft.

Modern Air Combat; The aircraft, tactics and weapons employed in aerial warfare today (223 pages) by Bill Gunston and Mike Spick is an in-depth study of the technology and tactics of modern warfare. The book is in three parts: technology of air warfare; today's aircraft and their weapons; and air combat tactics. The book has been extremely helpful in explaining how today's missiles and avionics are making the modern fighter pilot more efficient in an ever increasing complex environment.

On War (732 pages) by Carl Von Clausewitz is a collection of eight books on the subject of war. In his first book in the collection he describes the nature of war. In this description he explains about friction which occurs in war. This explanation was very helpful in the thesis to explain the "Fog of War."

Stealth Aircraft, Secrets of Future Airpower (96 pages) by Bill Sweetman, gives an interesting discussion of possible things to come in aircraft design. This book was useful for its information about the history of stealth

technology and where that technology is probably taking modern air warfare.

Technology and War (342 pages) by Martin Van Creveld is an analysis of technology's impact on warfare. It only covers airpower from its inception until 1945. This made good for background material for the thesis only.

U.S. FIGHTERS (352 pages) by Lloyd S. Jones, gives a brief history of every U.S. fighter to ever carry a "P" or "F" designation. This book was of value for its history of some of the aircraft discussed in the thesis.

GOVERNMENT PUBLICATIONS

Aces and Aerial Victories, The United States Air Force in Southeast Asia 1965-1973 (188 pages) from the Office of Air Force History, is a collection of first-hand accounts by Air Force fighter crews who flew combat missions over North Vietnam between 1965 and 1973. This book was extremely useful due to its first-hand accounts and statistics listed throughout.

Air Power in Three Wars (358 pages) by General William W. Momyer, USAF (Retired), is a perspective of how he viewed tactical airpower during World War II, the Korean War, and the Vietnam War. In particular, as Commander of the U.S. 7th Air Force in Vietnam from July 1966 to August 1968, and as Commander of TAC from his return from Vietnam in 1968 until his retirement in 1973 his views and insights into the air war in Vietnam were very informative and useful to the thesis.

Air Superiority in World War II and Korea (116 pages) by Richard H. Kohn is part of a continuing series of historical studies from the Office of Air Force History in support of Project Warrior. Project Warrior seeks to create and maintain within the Air Force an environment where Air Force people at all levels can learn from the past and apply the warfighting experiences of past generations to the present. The book is a first-hand account on the topic of air superiority by four air leaders who flew, fought, and

commanded tactical air forces in combat. The four air leaders are General James Ferguson, General Robert M. Lee, General William W. Momyer, and Lieutenant General Elwood R. "Pete" Quesada. General Ferguson in WWII commanded the 79th Pursuit Squadron, the 20th Pursuit Group, the 337th Fighter Group, and the 405th Fighter-Bomber Group. In Korea, General Ferguson was the Fifth Air Force Vice-Commander. General Lee did not fly or command directly in either WWII or Korea, instead he spent the bulk of his time organizing, training, and commanding tactical air forces in the United States. General Momyer in WWII flew in the North African campaign and during Korea was in professional military schools as either a student or as a lecturer. General Quesada in WWII commanded the XII Fighter Command in North Africa and the IX Fighter Command during the Normandy invasion. The book was useful only in its first-hand historical perspective of those periods. General Momyer's book Air Power in Three Wars proved to be much more detailed and as such, more valuable to the thesis.

The Battle For The Skies Over North Vietnam (190 pages) from the USAF Southeast Asia Monograph Series, is the story of US air superiority over North Vietnam. This story is told by the fighter aircrews who flew in Vietnam. This book was also valuable to the thesis for its first-hand accounts.

Battle for the Falklands (3) Air Forces (40 pages), by Roy Braybrook, is an interesting account of the Falklands

air war. The book was most useful to the thesis for its details in regard to the modifications which were made to the British aircraft.

Department of Defense, Dictionary of Military and Associated Terms (405 pages) is the source document for standard military terminology. This book ensured the use of standard definitions and terminology throughout the thesis.

Ideas, Concepts, Doctrine: Basic Thinking in the United States Air Force 1961-1984 (789 pages), by Robert Frank Futrell, is about the leadership of the Air Force and the Department of Defense and tries to explain the reasons and rational of why the leaders made the decisions they did. The Book was extremely useful in understanding the mindset of the leaders prior to and during Vietnam.

Lessons of the Falklands: Summary Report, by the U.S. Navy, presents an unclassified summary of Department of the Navy's study of the conflict in the South Atlantic. The report was useful to the thesis in its analysis of the personnel involved and of its evaluation of the Harrier itself and the tactics employed with the Harrier.

The Falklands Campaign: The Lessons (46 pages), by the British Ministry of Defence in December 1982, provides an assessment of the problems faced by the British forces in the Falklands. Although the report is written and published by the British government, the report admits to several severe problems encountered during the operation. The British

solutions to these deficiencies are briefly covered. The report was useful to the thesis for its evaluation of their air defence problems and limitations of the Harrier.

Mission Employment Tactics, Fighter Fundamentals F-16, (325 pages) by the USAF's Tactical Air Command, is an unclassified single-source, comprehensive document containing fundamental employment procedures and techniques for fighter aircraft for various missions. The document was helpful to the thesis as a reference to explain how fighter aircraft might fight in an aerial dogfight.

Post-World War II Fighters 1945-1973, Encyclopedia of U.S. Air Force Aircraft and Missile Systems, Volume I, (358 pages) by Marcelle S. Knaack contains basic information on all Air Force fighters developed between World War II and 1973. It is based primarily on U.S. Air Force sources. The origin of each aircraft, its' configuration changes, development, production, and operational problems are all noted is this account. This book was exceptionally useful for its level of detail in both historical and technical data about USAF aircraft from post World War II though Vietnam.

Quest for Performance, The Evolution of Modern Aircraft (545 pages) by the National Aeronautics and Space Administration (NASA), is a good account of the past 75 years of aircraft design and the advances made through technology. This is another book which was useful for its technical data on aircraft.

The United States Air Force in Southeast Asia 1961-1973 (383 pages) is an illustrated single-volume history of the USAF air activity in the Vietnam War. The book is limited in scope and depth about the air-to-air war, but makes no pretense of being a comprehensive history of the war and was of limited value to the thesis.

PERIODICALS

Aerospace Historian was used as a source for only one article, "Air Power, the Falklands, and the Principles of War," by Group Capt. Tim Garden of the Royal Air Force. The article provides a interesting analysis of the air war in relation to the ten principles of war.

Air Defense Artillery an unlikely source for the thesis provided some valuable information on the Israeli C3 and AWACS during Operation "Peace for Galilee." The article, "Lebanon: An Air Defense Analysis," is by U.S. Army Major Charles E. Mayo.

Air University Review was a source for two articles on the Falklands War. "Conflict in the South Atlantic: The Impact of Airpower," by Dr. Robert W. Duffner, examines the role and effectiveness of the airpower employed by both England and Argentina. "V/STOL: Neither Myth Nor Promise - But Fact," by a Royal Air Force Wing Commander John D.L. Feesey, discusses the Harrier and its abilities. Both articles useful to the thesis in helping me put together an understanding of the abilities of both sides in the Falklands conflict.

Airpower Journal had an article by Matthew M. Hurley, C1C, USAFA, entitled "The Bekaa Valley Air Battle, June 1982: Lessons Mislearned?" which proved to be an excellent reference for finding other sources.

Armed Forces Journal International provided four articles which were used in the thesis. Three of the articles dealt with USAF and U.S. Navy changes in training as a result of lessons learned from Vietnam. The articles are: "USAF's Fighter Crews Train to Win in TAC's Air Combat Program," and "'You Fight Like You Train' and TOP GUN Crews Train Hard," both by Armed Forces Journal International editor Benjamin F. Schemmer, and "Fighter Aircraft - the Cheap Shot Revisited," by retired USN Commander A.E. Waller. The fourth article, "Israelis Scored About 335 Air-to-Air Kills," discusses the dominance of the gun and heatseeking missiles for the Israelis in the Yom Kippur War.

Defense Electronics was a good source for the Israeli employment of the Grumman E-2C Hawkeye and its capabilities with the article, "Lebanon Proved Effectiveness of Israeli EW Innovations," was by David M. Russel.

Defense and Foreign Affairs aided the thesis with two articles about the Falklands War and two articles dealing with the Israeli's Operation "Peace for Galilee." The Falklands War article, "How Argentina's Air Force Fought in the South Altantic War" by Gregory R. Copley, discusses the difficulties the Argentine Air Force encountered in trying to fight an air war four hundred miles away. The two articles on the Israelis, "The Air War in Lebanon" and "The War Against Eagles," are both by the journals assistant editor Dr. Michael C. Dunn. "The Air War in Lebanon" looks at the aerial combat

by Israel in Lebanon, and "The War Against Eagles" examines the developments in defenses against hostile aircraft in both the Falklands War and Operation "Peace for Galilee."

International Defense Review provide useful articles on both the Falklands War and the Israeli Operation "Peace for Galilee." "The Falklands Conflict - Part I: The Air War," by Derek Wood and Mark Hewish, is an article dealing specifically with the air war in the Falklands War. "Israel Lashes Out," by R.D.M. Furlong, is an article based on a series of interviews with senior IDF officials and government officials prior to the Israeli Operation "Peace for Galilee." The article helps understand the feelings and philosophy of the Israeli leadership and the IDF toward its neighbors. The article is supplemented by the events of the Israeli Operation "Peace for Galilee."

Military Electronics/Countermeasures provided two very interesting articles about the Israeli's 1982 Operation "Peace for Galilee." The first article, "A U.S. Pilot Looks at the Order of Battle, Bekaa Valley Operations," by John V. Cignatti deals with the Israelis C3 and their efforts to deny the Syrians an effective C3. The second article, "Lt. Gen. Rafael Eitan: 'We Learned Both Tactical and Technical Lessons in Lebanon," by Paul S. Cutter was useful to the thesis for the Israeli's Chief of Staff of the IDF, Lt. Gen. Eitan's view about the operation.

Navy International provided an interesting article by Raymond V.B. Blackman entitled "Britain Invited Argentina Into Falklands." The article dealt with the military cut backs Britain made prior to the Falklands War which the author believes invited the Argentines to think that Britain would not fight for the Falklands because of these cut backs. The article was useful to the thesis in its information about the military cut backs Britain prior to the Falklands War.

USAF Fighter Weapons Review is published quarterly by the USAF Tactical Fighter Weapons Center and focuses its articles toward the tactical fighter community. It has been an excellent source of unclassified material on both past and current capabilities, practices, and lessons learned. Seven articles from this journal were used of which three are worth special mentioning. An article by USAF Lt. Col. Ralph L. Kuster Jr. of the Air Force Armament Laboratory entitled "Air-to-Air Missiles" gives a good evolution of guided missiles up to the end of the Vietnam conflict. Two of the articles deal with different aspects of air combat. "Being Fast," by USAF Major Mike Straight a Fighter Weapons School F-15 instructor pilot, discusses what speed really means in an air engagement. The other article, "The Fighter Pilot: Myth vs Reality," by Barrett Tillman examines the history of aerial dogfights in terms of the type of engagements fought by pilots up through Vietnam.

UNPUBLISHED PAPERS

"Airborne Early Warning and British Operations in the Falklands," by Major H. Alleyne Carter, is an examination of the British counterair campaign in the Falkland Islands War of 1982, and how the air defenses were handicapped by the lack of an airborne early warning system. The document was of great value for its excellent bibliography in the quest for literature about the Falklands War.

"Air-to-Air Continuation Training in the Tactical Air Command," by Major Branford J. McAllister provides a summary of the evolution of air-to-air training in the U.S. up through 1984. The report was of value for its discussion of training from post Korean War to just after Vietnam, and its bibliography.

"Argentine Air Power in the Falklands War," by Canadian Air Force Lieutenant Colonel Csaba B. Hezsely for the USAF's Air War College, looks at the Argentine force structure and their employment of air power. The report was useful for its analysis of the Argentineans employment of air power.

"Battlefield Air Interdiction in the 1973 Middle East War and Its Significance to NATO Air Operations," by Major Bruce A. Brant, is a historical analysis of battlefield air interdiction during the 1973 Middle East War. This thesis' bibliography was a good reference for helping find other sources concerning the Yom Kippur War.

"The Best Investment for the Air Superiority Fighter of the Year 2000: The Aircraft, Its Weapon System of Its Armament?" by Jean-Georges Brevot analyses the characteristics of modern air combat and the current technology trends. This was useful to the thesis for its explanations of current technological abilities, and also for its bibliography in locating other sources.

"Evolution of the Modern Dogfight," by Major Ronald L. Hanson, is a report done for the USAF's Air Command and Staff College, which examines some of the many changes that have occurred in the dogfight from its inception through Vietnam. The report is good for both its wealth of information concerning aerial dogfighting and its bibliography.

"Lessons From Israeli Battlefield Air Interdiction During The Battle For Golan, October 1973," by Major Thomas D. Entwistle, shows that Israeli air-to-surface operations during the battle were equivalent to current USAF doctrine for Battlefield Air Interdiction. This thesis was useful for its bibliography concerning the Yom Kippur War.

"Rules of Engagement: What is the relationship Between Rules of Engagement and the Design of Operations?" by Major Micheal A. Burton explains the role ROE plays in the use of military force as a political instrument. This thesis was of great help in trying to decide how to define and discuss ROE.

"Search for an Advanced Fighter: A History from the XF-108 to the Advanced Tactical Fighter," by R.P. Lyons gives an excellent history of the design of fighters from the lessons learned in Vietnam to the Advanced Tactical Fighter. This history along with its bibliography was useful to the thesis.

"War in the Falklands: Perspectives on British Strategy and Use of Air Power," by Lieutenant Colonel John E. Marr for Air War College, analyzes British response to the Falklands War, with emphasis on force selection, strategy, jointness of operations, and the role of air power. The report was useful for both its facts and its bibliography.

In conclusion, there is sufficient literature to support most of the thesis. The one weak area encountered was in training. Details about training, other than U.S. training, seems to be a topic which authors talk about in vagueness. Most of the Israeli training is classified so an indepth analysis of the IAF's training vs that of their Arab neighbors was not possible. The conclusions drawn on Israeli training in this thesis are based on the results the Israelis achieved in their conflicts and the importance they say they put on it.

See the attached bibliography for a complete listing of the references used.

APPENDIX 2

## APPENDIX 2

## GLOSSARY

AERIAL DOGFIGHT - Any air-to-air engagement in which both adversaries are within visual range of each other.

AWACS - Airborne Warning And Control System

BASIC FIGHTER MANEUVERS (BFM) - Aircraft flight maneuvers flown in relation to another aircraft to either attain a position from which weapons may be employed, deny the adversary a position from which his weapons may be employed, or defeat weapons already employed by an adversary. (AFM 3-3)

BVR- Beyond Visual Range

C3 - Command,control, and communications

CHAFF - Thin, light strips of foil or metalized fiber that may be scattered in the air to hide targets or otherwise confound the operation of an enemy's radars. The length of the strips is usually made equal to the wavelength employed by the radars the chaff is to be used against so as to

maximize the chaff's radar cross-section, thus creating false signals on radar scopes.

ELECTRONIC COUNTERMEASURES (ECM) - Measures, such as jamming and dispensing chaff, which are contrived to disrupt the operation of or deceive an enemy's radar.

HEADS-UP DISPLAY (HUD) - An optically transparent sheet, such as a sloping pane of glass, on to which symbology and alphanumerics are projected without getting in the way of the pilot's view ahead. The symbols and written data may tell the pilot such vital things as his speed, heading, altitude, attitude, and relevant weapon status and aiming cues. The information is electronically generated and focussed at infinity. This allows the pilot to keep looking ahead, either at an adversary or searching for one, without having to look inside his cockpit and refocus his eyes to see this information.

IAF - Israeli Air Force

IDF - Israeli Defense Force

NATO- North Atlantic Treaty Organization

RADAR CROSS-SECTION - A factor relating the power of the radio waves that a radar target scatters back in the direction of the radar to the power density of the radar's transmitted waves at the target's range. Takes account of the cross-sectional area of the target as viewed by the radar, the target's reflectivity, and its directivity.

RADAR HOMING and WARNING (RHAW) - A passive device which informs the pilot of radar signals other than his own.

RULES OF ENGAGEMENT (ROE) - Directives issued by competent military authority which specify the circumstances and limitations under which forces will initiate and/or continue combat engagement with other forces encountered.

U.S. - United States (of America)

USAF - United States Air Force

VISUAL IDENTIFICATION (VID) - Confirmed visual sighting and classification of an aircraft.

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