AU/ACSC/210/1998-04

AIR COMMAND AND STAFF COLLEGE

AIR UNIVERSITY

21ST CENTURY AIR-TO-AIR SHORT RANGE WEAPON REQUIREMENTS

by

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A Research Report Submitted to the Faculty

In Partial Fulfillment of the Graduation Requirements

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April 1998

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. REPORT DATE (DD-MM-YYYY)	2. REPORT TYPE	3. DATES COVERED (FROM - TO)
01-04-1998	Thesis	xx-xx-1998 to xx-xx-1998

4. TITLE AND SUBTITLE
21st Century Air-To-Air Short Range Weapon Requirements
Unclassified

5a. CONTRACT NUMBER
5b. GRANT NUMBER
5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Nichols, Stuart O. ;

5d. PROJECT NUMBER
5e. TASK NUMBER
5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME AND ADDRESS
Air Command and Staff College
Maxwell AFB, AL36112

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME AND ADDRESS
,

10. SPONSOR/MONITOR'S ACRONYM(S)
11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
APUBLIC RELEASE
,

13. SUPPLEMENTARY NOTES

14. ABSTRACT

Historically, a short-range weapon system was all that was available for air-to-air fighters. As a result, the gun has been a constant in aerial warfare. However, the advent of air-to-air missile technology and sophisticated airborne radar systems has changed the fighter pilot?s primary weapon of choice to longer range missiles. This trend is evident by highlighting the percentage of gun kills in relation to over all air-to-air kills. The percentage has shifted from 100% gun kills in WWI and WWII to 0% gun kills in the Persian Gulf War. The improvement in air-to-air missile performance has made the necessity of a gun system suspect. This advancing trend begs the question; is there a need for a short-range weapon in 21st century air-to-air fighters? This paper examines the requirement of equipping future fighters with a short-range capability by conducting a varied literary review. An examination of historical aerial engagements, modern training and technologies, as well as future trends provides sufficient information to make procurement decisions. Additionally, a prediction of future combat situations assists planners in developing air-to-air requirements. In conclusion, technology will surely allow for beyond visual range employment, although future missions will be predominantly low intensity conflicts restricted by political rules of engagement. These restrictions will limit the utilization of stealth benefits and missile advantages because fighters will be drawn into the visual arena where a short-range weapon system will be required.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE	Public Release	39	Fenster, Lynn lfenster@dtic.mil
Unclassified	Unclassified	Unclassified			19b. TELEPHONE NUMBER International Area Code Area Code Telephone Number 703767-9007 DSN 427-9007

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Abstract

Historically, a short-range weapon system was all that was available for air-to-air fighters. As a result, the gun has been a constant in aerial warfare. However, the advent of air-to-air missile technology and sophisticated airborne radar systems has changed the fighter pilot's primary weapon of choice to longer range missiles. This trend is evident by highlighting the percentage of gun kills in relation to over all air-to-air kills. The percentage has shifted from 100% gun kills in WWI and WWII to 0% gun kills in the Persian Gulf War. The improvement in air-to-air missile performance has made the necessity of a gun system suspect. This advancing trend begs the question; is there a need for a short-range weapon in 21st century air-to-air fighters? This paper examines the requirement of equipping future fighters with a short-range capability by conducting a varied literary review. An examination of historical aerial engagements, modern training and technologies, as well as future trends provides sufficient information to make procurement decisions. Additionally, a prediction of future combat situations assists planners in developing air-to-air requirements. In conclusion, technology will surely allow for beyond visual range employment, although future missions will be predominantly low intensity conflicts restricted by political rules of engagement. These restrictions will limit the utilization of stealth benefits and missile advantages because fighters will be drawn into the visual arena where a short-range weapon system will be required.

Chapter 1

Introduction

> *You can have computer sights or anything you like, but I think you have to go to the enemy on the shortest distance and knock him down from point-blank range. You'll get him from in close. At long distance, it's questionable.*
>
> —Colonel Erich "Bubi" Hartmann, GAF
> World's Leading Ace, Luftwaffe
> 352 Victories, WW-II

The genesis of air-to-air combat occurred in the skies over Europe during World War I. As aerial combat matured, control of the skies became imperative, so that armies were free to maneuver to capture vital positions on the ground. Aviation technology and armament was primitive and very limited. Airspeeds were slow and the only way to destroy an enemy aircraft was at close range with a gun mounted to the aircraft. This same capability was exhibited in World War II and the Korean War. It was not until the Vietnam War that missile technology made it plausible to shoot down an enemy aircraft beyond visual range (BVR). Modern technology has advanced so much that missiles can be fired from over 30 miles away, obviously diminishing the need for the classic dogfights. This trend begs the question; is there a need for a short-range weapon in 21st Century air-to-air fighters? This paper examines the requirement of equipping future fighter jets with a short- range weapon capability needed in visual dogfights.

The requirement to equip 21st Century air-to-air fighters with a short-range weapon system will remain a vital component of air-to-air combat, even though the trend has been to shoot from ever increasing distances. I will support this hypothesis by exploring the historical background of dogfighting, and how it relates to the present day emphasis on visual maneuvering. This discussion is followed by an analysis of modern day air-to-air principles and the technological advancements that may promote BVR engagements. Additionally, future air-to-air combat implications are examined with respect to technology, rules of engagement and possible missions. Finally, a summary of findings and recommendations are provided, so the necessity of equipping future fighters with a close range weapon can be debated.

Chapter 2

History of Air-to-Air Combat

> *As to gunnery passes, the best was when you dived with speed, made one pass, shot an opponent down quickly, and pulled back up…. The secret was to do the job in one pass; it could be from the side or from behind and I usually tried to open fire at about 150 feet.*
>
> —Major Erich Rudorffer, Luftwaffe
> Seventh leading Ace, WW-II
> 222 Victories (13 on One Mission)

An examination of air combats role in history highlights the fact that short-range weapons have been a relative constant in aerial warfare. The gun has always been a major weapon system in which air-to-air experts have vigorously trained. Aerial combat originated in World War I. Even though it did not play a decisive role in that war, it laid the foundation for a now vital fundamental component of warfare, air superiority. Joint Pub 3-56.1, *Command and Control for Joint Air Operations*, defines air superiority as:

> That degree of dominance in the air battle of one force over another which permits the conduct of operations by the former and its related land, sea, and air forces at a given time and place without prohibitive interference by the opposing force.[1]

Robert L. Shaw, in his book *Fighter Combat Tactics and Maneuvering* said control of the skies "allows strategic and tactical bombing, close air support of troops and armor, airborne or surface reinforcement and supply, reconnaissance, and other missions vital to the success of any military operation."[2] This dictum has remained true for nearly a

century and should persevere during the next century. But first, an examination of the past is in order.

World War I

The most renowned name in all of air combat is that of Manfred von Richthofen. Germany's "Red Baron" shot down 80 planes before himself dying in combat. He achieved his success by following eight commandments of air-to-air tactics devised by Oswald Boelcke. Boelcke was the German Air Service's leading ace at the time of his death with 40 kills. One of those commandments was to "...fire only at close range and only when your opponent is properly in your sights."[3] Today's guns can reach out to over 6000 feet however, it is still better to shoot at the closest range possible. Shooting at close range increases the chance of destroying your target by reducing bullet dispersion. Another commandment taught to the German pilots was to "...always keep your eye on your opponent."[4] This sounds intuitively obvious, but in a multi-target environment losing sight of the enemy can be fatal. Both of these mandates remain apropos in today's supersonic, radar and missile environment.

Limited armament and maneuverability drove early air-to-air tactics of World War I aircraft. Most engagements were quick decisive attacks, usually taking less than a minute to complete. Aircraft were visually acquired within a few miles and attacked by maneuvering behind the airplane and firing at it with the gun. The second leading French ace with 53 kills and a member of the famed French Lafayette Escadrille, Captain Georges Guynemer, said that the first 15 to 20 seconds would decide the fight. "He used to dive on his antagonist and hold his fire until the last possible moment."[5]

World War II

Tactics did not change that much during World War II. The aircraft could fly faster and higher, but the armament was the same, a gun that demanded precise aim under difficult conditions. Major General Claire Chennault commanded the Flying Tigers in China. Flying the P-40 he devised tactics to engage the more maneuverable Japanese fighters. He stated, "...use your speed and diving power to make a pass, shoot and break away."[6] He also stressed precise gunnery attacks at close range.

In *The Royal Air Force and the Battle of Britain*, Robin Higham remarked that "the British aircraft industry was producing some 59 different designs."[7] The common link amongst these aircraft was the armament—the gun. Although British pilots flew many different aircraft, employment tactics were similar. They would capitalize on aircraft advantages to maneuver into an favorable position and employ the gun in close combat.

Korean War

The Korean War introduced the F-86 Sabre as the first jet aircraft capable of speeds in excess of 600 miles per hour and combat ceilings over 35,000 feet. Still, it carried six .50 caliber forward firing machine guns as its only armament. There were times when over 200 aircraft were airborne at a time; the only way to ascertain an enemy aircraft was with visual identification. Therefore, fratricide was not a major problem because the limited range of the gun forced a visual confrontation. According to the first jet aircraft ace, Captain James Jabara, air-to-air combat consisted of visually acquiring the enemy, dropping external fuel tanks to increase maneuverability, and then "...maneuver to get into firing position. After all a fighter is simply an airborne gun platform."[8]

Following the Korean War, technological improvements led to a change in the prevailing theme of air-to-air combat. Hagner and Lynch, authors of *Air Combat*, said, "in the late 1950's, at the dawn of the supersonic age, the one-on-one, close-in dogfight was officially decreed obsolete."[9] The general trend in weapons development was initiated by a new philosophy that future engagements would take place BVR with sophisticated missiles. The U.S. started designing new fighters, such as the F-4 Phantom, without guns. It seemed obvious that the supersonic speeds of new aircraft would eliminate the need for the "archaic" close-range turning dogfights.

Vietnam War

This philosophy proved to be flawed, as air combat in the Vietnam War revealed. Missile technology was undependable. Missiles failed about 50% of the time. Missiles had problems detecting, tracking, and fuzing on enemy aircraft. Another major shortfall was positively identifying an aircraft as friendly or enemy when outside visual range. Fighter pilots relied on ground controllers to identify the aircraft for them. Identification was not always accurate because it depended on the reliability of the ground controllers radar and accuracy. The possibility of shooting down a friendly aircraft was extremely unattractive and absolutely unacceptable. Therefore, there were delays in positively identifying an aircraft, which necessitated a close range visual engagement. This provided the unenviable situation of being in a position behind an aircraft without the capability to shoot any type of ordnance. Without a gun, F-4 pilots were forced to break off engagements and return to friendly skies.

This trend away from gun production in fighters was reversed in the 1970s. Valuable "…combat experience had once again demonstrated the value of the gun and the

limitations of some of the more exotic weapons.''[10] In fact, the experience in the Vietnam War revealed that technological superiority was not a guarantee for victory. Although missiles provided an extra dimension, they could not replace the battle proven canon as a vital part of a fighter's arsenal and a key to survival in a dogfight. As a result, the U.S. started equipping F-4's with gun pods and later models with internal guns.

Israeli Air Combat

Israeli Air Force aerial victories over the Arabs in the Yom Kippur War in 1973 further proved the successful use of the gun. In fact, about 70% of their air-to-air victories were as a result of canon fire. But it was not until the late 1970s and the introduction of the arguably greatest air-to-air fighter in history, the F-15 Eagle, and the F-16 Fighting Falcon, that technology would make a quantum leap in the conduct of air combat. The Israelis were the first to test these sophisticated aircraft in combat. They fought the Syrian Air Force in the Bekaa valley in 1982. It was the first time in history that missile kills outnumbered gun kills. In this war, missiles produced 93% of Israeli kills. They were still mostly fired within visual range, but at greater range than a gun could be employed.[11] The gun was no longer the primary weapon of choice, but it was used in certain instances.

Persian Gulf War

The Coalition Forces assembled during the Persian Gulf War in 1991 used the lessons learned from the Israelis over Lebanon 1982. They attempted to destroy Iraq's ability to fight a war by precise bombing and control of the skies over Iraq. This minimized the use of ground forces in achieving our objectives, one of which was to

drive the Iraqi's out of Kuwait. The U.S. Air Force dominated the skies, but the amount of turning fights was limited. There were still many cases where visual fights occurred, but the BVR capability was exploited for the first time in air-to-air combat. In fact, for the first time in air combat maneuvering, there were no gun kills attributed to air-to-air fighters. Although missiles achieved all the kills, fighter pilots were provided an extra measure of comfort because they could use the gun, if needed. If missiles didn't function properly, the reliable gun was available for close range aerial engagements.

Summary

This review of 20th century air-to-air combat is noteworthy because it depicts the gun as the single constant air-to-air weapon system. This will, in turn, effect future training and weapon acquisition. The typical aerial engagement has been a visual maneuvering fight between aircraft. It is engrained in the training system used today. All new fighter pilots spend a majority of their training practicing high-g maneuvering, frequently resulting in a gun attempt. No doubt today's fighter pilots will train early 21st century F-22 Raptor pilots. They will most likely retain this bias slanted toward visual high-g maneuvering.

The decision to equip the F-22 Raptor with a gun has already been made. However, there are many other variables such as, modern air-to-air principles, Rules of Engagement, stealth technology, and mission-type, that will be factored into the decision of how to equip follow-on 21st century fighters. These factors will be discussed in Chapters 3 and 4.

Notes

[1] Joint Publication 3-56.1. *Command and Control for Joint Air Operations,* 14 November 1994, GL-4.

[2] Robert L. Shaw, *Fighter Combat Tactics and Maneuvering* (Annapolis: Naval Institute Press, 1985), 316.

[3] C.J. Hagner and J.M. Lynch, *Air Combat* (Alexandria: Time-Life Books, 1990), 110.

[4] *ibid.* 110.

[5] Stanley M.Ulanoff, *Fighter Pilot* (New York: Prentice Hall, 1986), 30.

[6] *ibid*. 150.

[7] Robin Higham, "The Royal Air Force and the Battle of Britain," in *Case Studies in the Achievement of Air Superiority*, ed. Benjamin Franklin Cooling (Washington D.C.: Government Printing Office, 1991), 148.

[8] *ibid*. 206.

[9] C.J. Hagner and J.M. Lynch, *Air Combat* (Alexandria: Time-Life Books, 1990), 22.

[10] Robert L Shaw, *Fighter Combat Tactics and Maneuvering*. (Annapolis: Naval Institute Press, 1985), 5.

[11] C.J. Hagner and J.M. Lynch, *Air Combat* (Alexandria: Time-Life Books, 1990).

Chapter 3

Modern Air-to-Air Principles

> *The contest for air superiority is the most important contest of all, for no other operations can be sustained if this battle is lost. To win it, we must have the best equipment, the best tactics, the freedom to use them, and the best pilots.*
>
> —Gen. William W. Momyer
> Former Commander, Tactical Air Command

This period in aerial history will lay the foundation for 21st century employment. An understanding of modern weapons capabilities and limitations can provide some insight to the question of whether there is a need for a short-range weapon in 21st century air-to-air fighters. This chapter discusses some modern air-to-air principles and terms. This analysis is important because it highlights some weaknesses in air-to-air missile technology. Aggressive dogfighting is still taught today and demands skill in precision gun employment because a missile might not be available. There are physical limitations, especially at close range, that prohibit missiles from being employed in certain instances. Also, it is possible that a pilot might have fired the entire missile load or had them defeated by various countermeasures. Therefore, the gun might be all that remains as a viable weapon for that particular engagement.

Basic Fighter Maneuvers

The technological capability of each era's fighter aircraft dictated that day's training regimen. Today's F-15 training is still focused on visual air combat maneuvering. According to the F-15 Fighter Training Unit (FTU) syllabus used at Tyndall Air Force Base, Florida, over 40% of their sorties are devoted solely to Basic Fighter Maneuvers (BFM) and Air Combat Maneuvering (ACM).[1] BFM is flown with two aircraft flying against each other. ACM is flown with two aircraft attacking a single adversary. Both situations involve visual close range setups. Success in visual air-to-air combat depends on the ability of the fighter pilot to maneuver his aircraft into a position from which he can employ ordnance against an enemy aircraft. If the pilot finds himself defensive and the opponent is behind him, success is defined as the ability to survive the attack and either kill the enemy or separate from the engagement alive. The maneuvers required to achieve these successes are termed Basic Fighter Maneuvers. These types of missions are demanding and ingrained in today's fighter pilot psyche.

Present day BFM training includes a building block approach beginning with offensive single ship maneuvering against a single enemy aircraft. In this case the trainee initiates the engagement aft of the "enemy" aircraft. Next, the trainee is introduced to defensive BFM, with the "enemy" initiating the engagement from behind. Finally, the trainee practices high aspect BFM. These engagements start with both aircraft pointing at each other, then both pilots attempt to maneuver into an advantageous position in order to "kill" their adversary. This favorable position is called the weapons engagement zone, or WEZ.

Weapons Engagement Zone

The WEZ is defined as the where a valid shot can be taken. The actual minimum and maximum WEZ ranges and position in relation to the enemy position is based on many factors, such as weapon, speed, altitude, g-forces available, and geometry. Today's fighter pilots continually practice maneuvering their fighters into the appropriate WEZ, with the intent to destroy the enemy. The gun WEZ is very small compared to a missile WEZ and is the most difficult zone to remain in long enough to achieve a valid shot. However, the gun WEZ possesses an exclusive area inside a few thousand feet where a missile can not be employed effectively. Most importantly, if you are unable to employ missiles, for whatever reason, the pilot's survival may depend on the ability to achieve a valid gun solution.

Gun WEZ

There is no real minimum range for the modern gun WEZ, but it entails pointing directly at the target. Although one should allow for time to pull away from the exploding fireball, 500 feet is used as a rule of thumb, before endangering your own aircraft by flying through debris. Maximum range is calculated by using muzzle, or bullet, velocity, among other factors. When shooting a bullet from a gun there is a certain range when the bullet runs out of energy and starts to tumble towards the earth. This approximates maximum range. Launch platform altitude and airspeed factor into this equation as well. Suffice it to say that the maximum range is somewhere inside of one nautical mile, or 6000 feet.

As mentioned earlier, the closer a gun shoots at a target, the higher chance of an accurate shot occurring based on bullet density at impact. The bullets don't have as much

time to disperse into a wider, less lethal, pattern. Simple trigonometry can explain that the farther away you are from a target, a small error in angular lead towards the target can be enough to miss the target. That is why the aces of previous wars recommend shooting as close to minimum range as possible to help “sweeten” the shot.

In the future, the maximum range will be greater due to more advanced weapons systems that can deliver ordnance more accurately and with more bullet velocity. A new system might be more reliable, cost effective and lighter weight. It could deliver ordnance in the form of lighter bullets, lasers, proton beams or particle beams. The principle remains the same though, aggressively maneuver your aircraft into a positional advantage behind the enemy and effectively fire from a valid WEZ, in case a missile WEZ does not present itself.

Missile WEZ

Before a valid launch from a WEZ can be achieved, the missile must “see” the target. Today’s technology provides two detection methods, temperature and radar tracking. Temperature tracking occurs in missiles such as the AIM-9 Sidewinder by having a seeker in the missiles’ nose track a hot emission from the target, such as engine exhaust. Tracking can also occur by acquiring a radar lock onto the target. The radar lock can come from on-board radar, which externally relays target information to the missile. Some examples of these missiles are the U.S. AIM-7 Sparrow and the former Soviet AA-10 Alamo. Finally, the missile itself can contain its own radar to achieve a solution, such as the AIM-120 Advanced Medium Range Air-to-Air Missile. In summary, a technologically complex series of events must occur for a missile to detect, track, and fire

on a target, assuming a launch in a proper envelope. A single failure in a software or hardware component will result in a missed opportunity.

Missile WEZs are drastically larger than a gun WEZ. In fact, you can be in a valid WEZ at any aspect to the enemy, in front of, or behind, as long as you are pointing towards the enemy. Maximum range can exceed 30 miles, while minimum range can be inside a mile, depending on missile g-capability and arming time. If the enemy is not maneuvering, a missile can be employed at closer ranges, almost competing with a gun. If the enemy is turning, the minimum range expands because the missile must perform a high-g turn in order to hit the target. Modern missiles can pull over 30 g's, or turn with over 30 times the force of gravity. This maneuverability is required at close ranges, so missiles can perform tight turns, thereby completing an intercept of a fast moving target. However this can be a severe limitation if the enemy has generated a high rate of turn. If too high, the g-limited missile will not maintain track throughout the intercept.

The minimum range of missiles is a limiting factor, but is constantly improving with missile software updates. Today's technology features gimbaled rocket motors that can turn the missile and apply thrust in the direction the missile needs to travel, not just straight ahead as in most rocket motors.[2] This drastic improvement in missile maneuverability will most likely decrease the minimum range of missiles, but will never have the minimum range of a gun due to maneuvering limitations, required arming time, and the limitations of its warhead.

Lethal Radius

It also takes a certain amount of time for the missiles to arm. You do not want it to arm immediately in case it detonates in front of your aircraft within range of its lethal

radius. Lethal radius highlights a physical limitation inherent in today's air-to-air missiles. Each missile warhead has a certain distance declared, or lethal radius, in which detonation of whatever killing mechanism it contains proves successful in destroying a target. In some missiles, a direct hit is not needed if it contains a proximity fuze, meaning the warhead will detonate if it is within a certain distance of the target.

The warheads used "...are typically blast-fragmentation types, incendiary or explosive pellets, or expanding-rod types." [3] The rods or pellets explode outward toward the target and cut through hydraulic lines or the cockpit itself to destroy the aircraft or pilot. The significance of lethal radius is that a missile must complete a highly complex intercept relatively close to an enemy aircraft, and fuze properly, in order for the warhead to detonate. Conversely, a bullet fired from a gun contains no warhead or proximity fuze. It causes damage by impacting the target at a high rate of speed.

Gun Benefits

This chapter has reviewed modern air-to-air principles of BFM along with key definitions. The aerodynamic limitations inherent in employing missiles at minimum range makes the gun weapon system crucial for tomorrow's combat arena. The gun is a simple weapon system to employ and maintain. It cannot be degraded by enemy electronic counter-measures or flare decoys which all help to degrade missile performance. Another significant benefit of using a gun is that it isn't reliant on the aircraft's radar system. Radar missiles must work in concert with the aircraft's radar, which is very susceptible to enemy aircraft maneuver and counter measures. Finally, the gun provides additional firepower and can be fired from an exclusive WEZ.

Summary

The gun benefits will not disappear in the 21st Century. The gun provides a fighter pilot an additional weapon that rarely malfunctions. By highlighting the inherent limitations of modern missiles, the requirement to equip future fighters with a short-range weapon should remain. As previously noted, the gun has been a constant in aerial warfare. An examination of future implications and missions will help us decide if this constant will remain.

Notes

[1] 19AF Syllabus F-15 ACBOOAT, *USAF Basic Operational Training Course, F-15*, August 1996.

[2] "Russian Missiles Heat Up Western Market," *Jane's Defence Weekly*, 6 November, 1996, 27-30.

[3] Robert L. Shaw, *Fighter Combat Tactics and Maneuvering* (Annapolis: Naval Institute Press, 1984), 45.

Chapter 4

Future Implications

> *…the U.S. must prepare to face a wider range of threats, emerging unpredictably, employing varying combinations of technology, and challenging us at varying levels of intensity.*
>
> —Joint Vision 2010

Training syllabi for future air-to-air platforms will have to balance the amount of training it should allot to maneuvering in the visual and BVR arenas. The advancements in avionics technology, aircraft performance and weapon capabilities will dictate the proper percentages. The requirement will be based on available technology and predictions of typical future aerial engagements. Future technology will continue to provide the ability to obtain long range contact on the enemy, and employ BVR weapons. That capability, coupled with our radar evading stealth technology might make the classic dogfight obsolete. However, pure technology is not the only factor that determines tactical employment. The type of mission and political climate of the time will provide certain rules and limitations allowing a fighter pilot to engage an enemy. The requirement to shoot a target at close range will remain vital.

Rules of Engagement

Theater rules of engagement, or ROE, will be a major factor affecting the initiation of 21st century engagements. It is difficult to predict the magnitude of future wars or

skirmishes. They might be total war, low intensity conflicts, or peacekeeping missions. Hopefully, nothing like the enormity of World War I or World War II will take place. Since we will live in a multi-polar world, and assuming a trend away from total war, the most likely conflict will be a low intensity conflict. Small-scale wars actually wreak havoc amongst campaign planners, particularly in the area of designing an offensive air campaign plan. They must design a plan with straightforward ROE that provide air-to-air fighters with the ability to prosecute an attack and fire ordnance without severe limitations.

The most recent example of writing rules of engagement in warfare took place during Operation Desert Storm in the Persian Gulf War of 1991. According to Colonel David A. Deptula, Director of the Iraqi/Strategic Targeting Cell and the Director of the Campaign Planning Cell, constructing rules of engagement was a very involved process. Lawyers from the Air Force Judge Advocate General were involved to ensure that the laws of warfare and the Geneva Convention were observed. They advised the planners if any type of legal concern surfaced. With this legal support the offensive campaign planners, directly supervised by the Joint Force Air Component Commander, wrote the rules of engagement.[1]

Many factors are considered, such as the various identification platforms available in theater. This includes the fighter aircraft executing the attack, as well as other types of control and intelligence platforms, such as Airborne Warning and Control aircraft and the Rivet Joint. The scenario and plan being executed is also a driving force. If an offensive gameplan is executed in a low intensity conflict, the rules will be more stringent. If a defensive role is performed, then the rules might correspondingly be more lenient.

Desert Storm intelligence reports of threat capability were also paramount. Planners wanted to ensure that fighter pilots were given every opportunity to employ effectively and with an advantage. The Commander-in-Chief of all deployed forces, General Norman Scwartzkopf, approved the rules. The final product was sent to the National Command Authority where the President ultimately approved the ROE. Obviously, future war ROE will be politically motivated and driven, possibly diminishing a fighter pilots tactical advantage.

The above mentioned example of this modern day process has evolved since the beginning of aviation warfare. The advent of technologies has made it a much more difficult problem. So many factors are involved that it is difficult to ascertain an aircraft's identity when you are in a BVR environment. Additionally, many countries possess the same systems and might some day be adversaries. Assuredly, technological advancements will make it more complex and national leaders want to ensure that collateral damage be kept to a minimum if not eliminated entirely. Finally, public opinion is a crucial determinant of national policy. Today the American public is better informed and this trend is sure to expand, especially with the real-time access the media has to world events.

The smaller the scale of conflict, the stricter the rules of engagement will be. Future conflicts will indeed fit this mold. These rules will limit the advanced fighters of the future and their ability to employ to their fullest extent. If civilian aircraft of friendly or non-belligerent nations are in the air in close proximity to the warring factions, BVR authorization might be impossible. The rules of engagement might be so stringent that a

visual confrontation might be inevitable and BFM prowess will once again be a requisite, directly leading to employment of a short-range weapon.

Stealth Technology

The Air Force has possessed stealth technology for almost 20 years. The unveiling of the F-117 Stealth Fighter from secrecy proved it's worth as an excellent nearly radar-invisible bombing platform during the Persian Gulf War. The Air Force is continually conducting research and development for better aircraft to replace the modern-day fleet. It is true today as the full-scale development of the Advanced Tactical Fighter, or F-22, comes to fruition.

The stealthy F-22 is an air superiority fighter designed to replace the F-15, so that it too can dominate the air-to-air arena. One of the key elements of this aircraft is the low radar observability it possesses. The goal is to construct a fighter that will see the enemy before it sees them and shoot to kill before they have a chance to defend themselves. It takes almost 30 years for a sophisticated fighter to transition from the concept and design phase to the full production phase. In that time, existing technologies become almost outdated.

Today, improvements in stealth technologies that are being tested "...could make warplanes virtually invisible to radar, infrared sensors and the human eye."[2] The aircraft being tested have a special coating that make this possible. In fact, "...the coating has properties that allow aircraft's skin color to be changed to blend the aircraft into the sky if viewed from below, or various hues of earth if seen from above.[3] Another futuristic possibility involves capturing an enemy radar signal, reproducing that signal and sending a return radar signal that masks the friendly fighter.

In the future, stealth advantages, coupled with stringent rules of engagement, or system malfunctions, could force friendly fighters into a visual confrontation. History has proven that our enemies eventually catch up with existing technologies and capabilities. The U.S. might be forced into a combat scenario with a country that is an ally today and possesses the same capabilities. This would place stealth forces against stealth forces, with neither side able to employ BVR weapons, instead relying on short-range weapons.

Air Force 2025

The Air Force conducted a study entitled *Air Force 2025* to examine future capabilities the U.S. will need to remain a dominant force in the 21st Century. One of the subjects was the Counter Air mission and how the U.S. will accomplish it. The report discussed three avenues of approach. The first was "...an evolutionary trajectory based on projections of current and programmed capability."[4] The other avenues dealt with unmanned vehicles or space-based systems performing the mission.

The Air Force report surmised that dogfights would occur in the future, even with a gun. It also stated that "...the counterair mission will require a variety of weapons to use against the entire spectrum of threats and available countermeasures. The gun will remain a lethal weapon when everything is electronically jammed or laser blinded."[5] In all cases, the Air Force will not make revolutionary changes, but evolutionary improvements.

Air Force 2025 discussed the many off-aircraft systems, or multi-spectral sensors, that will be required to provide positive identification of enemy aircraft. A problem may arise when fusing together many complex technological sources from satellites or data-link systems. If this happens, or stringent rules of engagement are in effect, the fighter pilot might be forced into a visual confrontation where the gun is the weapon of choice.

Notes

[1] Col David A. Deptula, interviewed by author, 31October 1997.

[2] David A. Fulghum, "Groom Lake Tests Target Stealth,." *Aviation Week and Space Technology*, February 1996, 26.

[3] David A. Fulghum, "Pilots to Leave Cockpit in Future Air Force," *Aviation Week and Space Technology*, 5 February 1996, 26.

[4] Rick W. Lester, et al., *Counterair: The Cutting Edge*, (Paper presented to Air Force 2025 at the Air University, 1996), vii.

[5] *ibid*. 8.

Chapter 5

Future Missions

> *The U.S. military faces a challenging future in an area of dynamic change, constrained resources, potential new roles, and rapid technological development. These factors require innovative thinking and new ways to shape change if we are to retain our worldwide position of leadership as we respond to future challenges.*
>
> —Concept for Future Joint Operations

It is extremely difficult to predict what type of warfare will take place in the future. "Geopolitics tend to be less predictable and quickly influenced by world events."[1] However, an accurate prediction is crucial in determining what weapon systems to use in fighters and more specifically, whether the U.S. should equip 21st century fighters with a short range weapon system. First, this chapter predicts how states will interact in the future. It utilizes this global interaction theory as a precursor to two probable military scenarios requiring air-to-air fighters, Military Operations Other Than War (MOOTW) and urban warfare.

State Interaction

The end of the cold war brought with it the end of the bi-polar world. The United States emerged as the world's only super power, but it is possible that many other countries or regions will rise as super powers. "Different models of the next international system have been put forward by analysts, journalists, politicians, and other observers of

contemporary international affairs."[2] A multi-polar world is one version that may emerge as the new international order. In this model, many states play vital roles in shaping the international arena. The traditional military and economic powers are important, but other measures such as culture and beliefs will play a prominent role in measuring power.[3] The existence of multiple powers in the world will provide a more even playing field for possible warring factions. Additionally, the existence of advanced communications will promote technological equality.

Today's Internet will be an archaic system; a horse and buggy compared to 21st century communications systems. An overlapping set of electronic networks will easily integrate states, so it will be simple to share data and technologies. Global acquisition of advanced technologies might place the United States on equal footing with less powerful adversaries, especially if a state is taken over by radical fundamentalists. The political change could affect regional stability and ultimately global security.

A multi-polar world presents an opportunity for more states to become recognized as significant contributing members of the global community. Modern third world nations will be clamoring to achieve economic prosperity and advancement in the 21st century. It is in these underdeveloped regions, primarily located in Africa and Asia, where conflict will take root, as they struggle for equality. Most of these states will not possess as robust a military as the United States, but enough capability, especially if they obtain weapons of mass destruction, to cause concern. By focusing on this type of environment, the air-to-air community might not be able to capitalize on the technological advances it has achieved in the BVR arena. Nevertheless, it might be in the best interest of the U.S. to engage in military operations within these poor areas, where turmoil and conflict exist, to

help preserve or create new democracies. By assuming a multi-polar world where information and technology exchange proliferates, even within combustible third world nations, the two 21st century missions most likely to force the U.S. into combat operations will be Military Operations Other Than War (MOOTW) and urban warfare.

MOOTW

"From a strategic perspective, patterns of conflict that we have experienced since about 1989 will likely continue into the 21st century."[4] Possible MOOTW include humanitarian assistance efforts, such as Operation Provide Comfort in Northern Iraq: non-combatant evacuation, such as Operation Assured Response in Liberia; peace operations such as those in Haiti and Bosnia, and finally mission such as Restore Hope in Somalia. In Somalia, air-to-air fighters were not even deployed to that theater because the warring factions did not possess a viable air threat. However, the U.S. may participate in MOOTW during the 21st century where an air-to-air threat exists, albeit a limited one. Air-to-air fighters could be used to enforce an exclusion zone, ensure freedom of navigation and overflight, peace operations or as a show of force.[5] Historically, MOOTW have taken place in poor nations that have not been on the leading edge of technology with respect to military equipment. But it is possible they could possess outdated fighter aircraft in the 21st century, such as the F-16. The F-16 has been sold to many nations and could possibly be the mainstay of many states' air forces in the future. Even though it will be outdated with respect to the F-22, it will still be lethal if it arrives undetected into an aerial engagement.

In this particular scenario, the U.S. would enjoy an enormous technological advantage over a less sophisticated enemy and would not require a close range weapon

system to succeed in an aerial battle. Fifth generation fighters, like the F-22, would use its superiority in radar, stealth, and missile technology to adequately defeat fourth generation fighters, such as the F-16. A possible limiting factor would be the more stringent Rules of Engagement used for MOOTW. This could equalize fighter capabilities by denying BVR capabilities and force a visual encounter, where a gun might be required for last second shot opportunities.

Urban Warfare

"Demographic trends indicate a tremendous increase in the numbers of people moving to and living in urban areas. By 2010, nearly two-thirds of the world's population will be urbanized."[6] The security implications of this are significant. First, the probability of urban warfare increases due to the fact that there will be less open space. Second, urban areas will contain vital lines of communications and transportation nodes. Additionally, cities will become the preferred location for potential enemies to operate in, in hopes of avoiding a conventional military confrontation.[7] Finally, Military Operations in Urban Terrain, or MOUT, provide many operational and tactical challenges; target identification and logistical support are difficult and mobility and fire support is also reduced.

The 1997 Chairman's Program Assessment emphasized MOUT as a major shortfall in current joint doctrine. The Chairman of the Joint Chief's of Staff stressed that improvement in infantry and close support weapons systems, munitions, and tactics are needed. Air superiority will be required for MOUT, allowing Close Air Support aircraft to operate unimpeded. Although target identification is difficult for ground attack aircraft, the air-to-air requirements remain unchanged. The main problem will be positively

identifying enemy aircraft amongst several friendly aircraft loitering over the urban area of operations. Once again, rules of engagement might not allow BVR employment. If it is allowed, positive identification by electronic means will be required prior to shooting. This presents a difficult problem with numerous aircraft in close proximity. If not accomplished, a visual identification will be required, thereby eliminating the advantages of BVR employment capability. Once again, fighter pilots might have to rely on a close range weapon system.

Summary

Chapter 2 established the gun as a reliable constant in aerial warfare throughout the 20th Century. This chapter's discussion of two plausible missions, conducted in a multi-polar world, further promotes the gun as a valid weapon of the future. A short-range air-to-air weapon will remain a constant in the 21st Century.

Notes

[1] Joint Chiefs of Staff *Concept for Future Joint Operations* (Washington D.C.: Government Printing Office, May 1997), 8.

[2] Daniel S. Papp, *Contemporary International Relations 4th Edition* (New York: Maximillan College Publishing Company, 1994), 207.

[3] *ibid*. 208.

[4] Joint Chiefs of Staff. *Concept for Future Joint Operations* (Washington D.C.: Government Printing Office, May 1997), 8.

[5] Joint Chiefs of Staff .Joint Publication 3-07, *Joint Doctrine for Military Operations Other the War* (Washington: Government Printing Office, 16 June 1995),Chapter III.

[6] Joint Chiefs of Staff *Concept for Future Joint Operations* (Washington D.C.: Government Printing Office, May 1997), 8.

[7] Lt Col Duane Schattle, "Urban Warfare," lecture, Air Command and Staff College, Maxwell AFB, Al., 16 September 1997.

Chapter 6

Conclusions and Recommendations

> *The counterair mission will require a variety of weapons to use against the entire spectrum of threats and available countermeasures. The gun will remain a lethal weapon when everything is electronically jammed or laser blinded.*
>
> —Counterair: The Cutting Edge
> Research Paper Presented to Air Force 2025

Summary of Findings

The decision to equip 21st century fighters with a short-range weapon has far-reaching implications. It causes a ripple effect regarding the conduct of other important issues such as, future missions and training. The goal is to provide America's fighting force with the best capability, within fiscal restraints, to protect American interests and support the President's National Security Strategy. This paper has argued in favor of equipping future fighters with a short-range weapon. This chapter will summarize these findings and the implications they provide for the future.

PROS

The history of a fighter combat has provided countless examples of the lethality of a gun. It was the only air-to-air weapon available for over 50 years. Therefore, it helped form a deep-rooted bias in favor of using a gun. The gun has proven its worth as a valid and lethal component of all fighters from the lethargic Sopwith Camel to the supersonic

F-15 Eagle. The gun has always been a reliable, easily maintained, weapon provided at relatively low cost. This deep-rooted bias still permeates today's fighter squadrons. There is a significant emphasis in today's training programs that teach new pilots how to aggressively maneuver into a valid gun WEZ. This, in turn, gives the pilot the confidence required of flying a sophisticated and demanding fighter aircraft.

This paper has highlighted a few other subjects that support retaining a gun capability. First, there are several limitations found in modern air-to-air missiles, especially at short range. The gun provides the added flexibility and capability to prosecute the attack at ranges inside one mile when missiles fail or are unavailable. Second, rules of engagement may sometimes limit the ability to shoot missiles BVR. The identification requirements might be so demanding that it simply takes too long to meet these requirements before a visual aerial engagement inevitably results. In this situation, it is comforting for a fighter pilot to know he has a gun available in case his missiles are defeated or unusable. Another case that supports retaining a short-range capability is the advent of stealth technology. History has shown that once a technology has been exhibited, the capability is quickly shared with the world. The communication advancements of tomorrow will support this, thereby allowing adversaries to equip their forces with radar evading aircraft. Technology might become so advanced that neither opponent will "see" each other BVR, thus leading to a visual engagement where, once again, a short-range weapon could be necessary.

Finally, this paper addressed future missions in which fighter a/c will be used. MOOTW and MOUT might be the most prevalent types of conflict in the 21st century. Both of these missions are inherently political in nature, where combat occurs short of

total war. In these cases, ROE, Urban terrain, and less formidable adversaries might all lead to situations where BVR capabilities cannot be capitalized. Identification and political restraints might force close range engagements requiring short range weapons.

Cons

This paper has also highlighted some reasons why a short-range weapon system might no longer be required. The most obvious argument against its future requirement in that the trend of actual kills has gone away from gun kills. All victorious aerial engagements were as a result of the gun up to the Vietnam War. It was then that the tide started to turn, resulting in zero kills attributable to the gun during the Persian Gulf War. One can argue that the advent of missile technology and radar performance has made the gun obsolete and unnecessary. The gun WEZ is so small that the percentage of times a gun would be the only viable option is minimal. Undoubtedly, research and development of missile technology will improve the minimum range capability of a missile, nearly approximating that of the gun. Additionally, countermeasure technology will improve so missiles will have a better chance of completing an intercepting and fuzing on a target.

The United States holds an impressive advantage with stealth technology. The design of the F-22 allows it to “see” a target, shoot, and kill the enemy, before the adversary has the opportunity to detect the F-22. This first look, first shot capability provides the F-22 with a tremendous advantage in the BVR arena. It can dominate the opposing force without being detected by radar or visual means. Certainly money spent on a gun is unwarranted and can be better spent on other aircraft systems.

Finally, the defense industry has always employed a significant work force that explores new technologies. Their objective is to design weapon systems, with more

speed, precision, lethality and maintainability. Advances in laser technology and particle beam energy can be used in short-range weapon systems. These systems might combine the advantages of both the gun and air-to-air missiles into one system that cannot be jammed or defeated by maneuver.

Implications

This paper has focused on answering the question, is there a need for a short-range weapon in 21st century air-to-air fighters? An exploration of the history of dogfighting and how it relates to the modern emphasis of visual maneuvering was beneficial because it showed the gun as a constant in aerial combat. The discussion of modern air-to-air principles and technological advancements assisted in answering the research question. Also, the discourse on future implications and missions established that the close range weapon would remain vital in the 21st century. A multi-polar urban world will provide the backdrop for lower intensity conflicts where political restraints and ROE will draw in the reigns of superior weapons. The BVR advantages will be diminished into an arena where ill equipped adversaries will be provided a fighting chance in classic dogfights. In this case, mission will outweigh technology.

Recommendations

Armed with a requirement to preserve a short-range weapon capability, U.S. forces can design training programs that still demand proficiency in flying a fighter into a short-range WEZ. However, the percentage of visual training can be drastically reduced, due to stealth and avionics technology, so as to exploit the improved BVR capability. Additionally, the defense industry should continue to explore new innovations to

decrease the air-to-air missiles minimum range. Finally, new systems should be developed to replace the gun, providing greater range and accuracy. The ability to use these advanced systems to there fullest is predicated on the environment in which combat will take place. It is difficult to predict the conditions surrounding future combat, but the U.S. should be prepared to prevail in any situation. A short-range weapon system must be retained to provide a fighter pilot every possible option in combat.

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