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THE QUEST FOR AIR DOMINANCE:
F-22—COST VERSUS CAPABILITY

by

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Abstract

Since the incorporation of the airplane into military service, air superiority has been a key ingredient to success on the modern battlefield. *Global Engagement: A Vision for the 21st Century Air Force*, the USAF's latest vision statement, lists air and space superiority as the first of six Air Force core competencies. The F-15 Eagle is currently the USAF's primary air superiority fighter. Designed in the 1960s and introduced into service in the mid-1970s, the F-15's status as the world's premiere air superiority fighter is being challenged by new fighter designs from numerous countries, as well as the proliferation of advanced surface-to-air missile systems. The F-22 is the USAF's follow-on air superiority fighter to the F-15. The design features of stealth, supersonic cruise, integrated avionics, and sustained maneuverability will provide the F-22 with a first look, first shot, first kill capability in all environments, against all current and planned future threats. However, at \$102 million a copy, the F-22 is by far the most expensive fighter the USAF has ever pursued. Along with the collapse of the Soviet Union, today's environment of shrinking defense budgets has called into question the necessity of buying the F-22 at all. Although there are a number of less expensive alternatives, none of them approach the combat capability of the F-22. The USAF is scheduled to buy 339 F-22s which will reach initial operational capability in late 2004. This schedule must be maintained in order to ensure the USAF can provide air superiority for U.S. forces in the future.

Chapter 1

Introduction

Since the airplane first saw military service in World War I, air superiority has been a key ingredient to success on the modern battlefield. The first aerial engagements were crude attempts by each side to prevent the other from conducting aerial artillery spotting and reconnaissance. Since those first dogfights in 1914, air forces throughout the world have sought more effective and lethal means to control their adversaries' abilities to exploit the aerospace medium. Today these means include a multitude of systems such as early warning radar and passive detection systems, airborne surveillance and command and control (C²) aircraft, surface-to-air missile (SAM) and anti-aircraft artillery systems, as well as the traditional air-to-air fighter. From an offensive perspective, however, it's the manned fighter aircraft that provides the best means to destroy an adversary's air power capability. While it's preferable to destroy an enemy's air forces on the ground, this may not be possible in the face of strong enemy integrated air defenses. For this reason, the U.S. needs fighter aircraft with superior air-to-air capabilities. The USAF currently fills this need with the F-15C Eagle. During Operation DESERT STORM, USAF F-15s quickly established air superiority over Iraq. As a result of the beatings they took during the first couple of days of the war, Iraqi pilots chose not to fly; ensuring

coalition air supremacy and giving rise to the joke that the three most feared words of Iraqi fighter pilots were: “Cleared for takeoff!”¹

Designed in the 1960s, strictly for the air-to-air mission, and introduced into service in 1974, the F-15 is recognized as the premier air superiority fighter in the world today. However, this status is being challenged by new fighter designs from numerous countries. The development of advanced SAM systems, such as the Russian-built SA-10 and SA-12, will also limit the F-15’s ability to operate effectively in enemy airspace. The F-15 is, in effect, rapidly approaching parity with new fighter designs that will become operational by the turn of the century. Consequentially, the USAF needs to modernize its air superiority capability now in order to meet the challenges of an uncertain future.

The F-22 Raptor is the USAF’s follow-on air superiority fighter to the F-15. The design features of stealth, supersonic cruise, integrated avionics, and sustained maneuverability will provide the F-22 with a first look, first shot, first kill capability in all environments. The USAF is scheduled to buy 339 F-22s which will reach initial operational capability in late 2004. This schedule must be maintained in order to ensure the USAF can provide air superiority for U.S. forces in the future. However, at \$102 million a copy (FY2004\$), the F-22 is by far the most expensive fighter the USAF has ever pursued. The breakup of the former Soviet Union, today’s environment of shrinking defense budgets, and the F-15’s excellent performance during Operation DESERT STORM, have all called into question the necessity of buying the F-22 at all. This paper will investigate the value of air superiority, the emerging fighter designs and other systems that threaten our ability to achieve it, and the unique capabilities of the F-22, in

an effort to determine if the advantages the F-22 brings to the fight are worth the new fighter's hefty price tag.

Notes

¹ Benjamin S. Lambeth, "To Dominate the Skies," *Armed Forces Journal International* 133, no. 4 (November 1995): 35-37.

Chapter 2

The Argument For Air Superiority

If we lose the war in the air, we lose the war, and we lose it quickly.

—Field Marshal Bernard Montgomery

Air and Space Superiority is the first of six Air Force core competencies and is the foundation upon which all other missions and capabilities are built. Air Force Basic Doctrine defines air superiority as “that degree of dominance that permits friendly land, sea, and air forces to operate at a given time and place without prohibitive interference by the opposing force.”¹ Air superiority is not an end in itself and stands little chance of winning wars alone. It is, however, the prerequisite first step that will enable the joint force commander (JFC) to conduct any campaign quickly and with minimum losses. While gaining air superiority is critical to success, the failure to do so will be disastrous. Without air superiority, the best the JFC can hope for is a long, drawn out war of attrition, with the possibility of total defeat never far away. The Battle of Britain stands as a classic example of the importance of air superiority and the disastrous results awaiting the force that fails to achieve it.

When Hitler ordered the Luftwaffe to shift its targeting priority from the Royal Air Force (RAF) to terror bombing British cities, he unknowingly sealed the fate of the Third Reich. This targeting shift gave the RAF, which was on the verge of collapse, time to rebuild its fighter forces and continue to inflict heavy losses on the Luftwaffe. By failing

to achieve air superiority, the Luftwaffe was never able to destroy the RAF. With the RAF intact, the Luftwaffe could not seek out and destroy the Royal Navy, which was the force preventing Germany from launching Operation Sea Lion, the cross channel invasion of the British Isles. Without the invasion, Germany was unable to knock Britain out of the war before Hitler ordered Operation Barbarossa, the invasion of Russia, in the spring of 1941. Failure to force Britain to sue for peace had two profound impacts on the outcome of the war. First, it forced Germany to fight a two-front war, requiring her to split her forces between east and west. Second, and more importantly, it provided the Allies with a foothold in Europe for mounting and launching their counteroffensive. Britain was the debarkation point for massive lend lease shipments of war materiel from the U.S., home of the 8th Air Force and the launch point for the Combined Bomber Offensive, and the embarkation point for the Normandy Invasion in June 1944. Failure to achieve air superiority over Britain in the summer of 1940 began the domino effect which ultimately led to Germany's surrender five years later.

In articulating the U.S. national security strategy in May 1997, President Clinton outlined three core objectives he claimed are essential to advancing the goal of a safer, more prosperous America. They are:

- To enhance U.S. security with effective diplomacy and with military forces that are ready to fight and win.
- To bolster America's economic prosperity.
- To promote democracy abroad.

He goes on to say that to achieve these objectives, the U.S. will remain engaged and provide leadership abroad.² Taking this stance means that wherever conflict exists in the world, the U.S. will most likely be found there. This strategy will require the U.S. to maintain a strong military capable of winning "two overlapping major theater wars."³ In

the event the military instrument of power is used, air superiority will be a critical first priority. It is the enabler that provides joint forces freedom from attack and allows them the freedom to attack. It is required for, and is part of, the operational concepts of Dominant Maneuver, Precision Engagement, Full-Dimensional Protection, and Focused Logistics, as outlined in *Joint Vision 2010* by former Chairman of the Joint Chiefs of Staff, General John M. Shalikashvili.⁴ The other five Air Force core competencies: Global Attack, Rapid Global Mobility, Precision Engagement, Information Superiority, and Agile Combat Support, are all dependent, either wholly or in part, on our having first established air superiority.

As noted earlier, during the 1991 Gulf War, the U.S.-led coalition enjoyed air supremacy—“that degree of superiority wherein opposing air forces are incapable of effective interference anywhere in a given theater of operations.”⁵ However, the coalition had seven months to deploy and build up forces before launching its counteroffensive. Future U.S. opponents will undoubtedly learn from Operation DESERT STORM, conducting continuous operations that require our forces to deploy into hostile environments. A RAND Corporation analysis conducted in late 1993 concluded that “the lesson from the Gulf War is not that the U.S. has enough airpower to meet future needs but that the capabilities exhibited in that war are a national asset that Washington should preserve and extend.”⁶ By the turn of the century, America’s air superiority mainstay, the F-15, will be over 25 years old. As will be shown in the next chapter, the threat to the U.S. ability to achieve air superiority in the future is not only real, but growing steadily.

Notes

¹ Air Force Doctrine Document (AFDD) 1, *Air Force Basic Doctrine*, September 1997.

Notes

² The White House, *A National Security Strategy for a New Century* (Washington, D.C.: Government Printing Office, May 1997), i.

³ Ibid, 5.

⁴ Department of the Air Force, *Global Engagement: A Vision for the 21st Century Air Force* (Washington, D.C.: Office of the Secretary of the Air Force, 1997), 10.

⁵ AFDD 1.

⁶ Russell D. Shaver, Edward R. Harshberger, and Natalie W. Crawford, “The Case for Airpower Modernization,” *Air Force Magazine*, February 1994, 46-52.

Chapter 3

Emerging Threats

The United States does not have a God given right to air superiority.

—General Ronald R. Fogleman

With the collapse of the Soviet Union, many critics argue that advanced systems such as the F-22 are not needed. In the years immediately following Operation DESERT STORM, and even today, this argument may be true. However, by the turn of the century, many U.S. airpower assets will be surpassed in capability by a number of foreign systems currently under development. Both Britain and France have built special complexes where “black” projects such as stealth aircraft designs can be tested away from prying eyes.¹ In 1987, the USAF discovered that Germany had been working on their Medium Range Missile Fighter, or Lampyridae, in total secrecy since 1981. They were also startled to learn that the supersonic Lampyridae used the same radar scattering techniques as the then top-secret F-117 Stealth Fighter.² The fact is that the U.S. doesn’t have a monopoly on new technology, and unless our current fighter force is modernized, we risk losing our ability to gain air superiority in any future conflict. The emerging threats that will challenge our ability to achieve air superiority in the future: advanced fighters, SAM systems, and air-to-air missiles, are discussed in more detail in the following sections.

Advanced Fighters

Advanced fighter aircraft are proliferating throughout the world. According to the Defense Intelligence Agency (DIA), the number of countries possessing advanced fighters grew from 17 to 50 between 1985 and 1995, and is expected to reach 62 by 2005.³ China has already bought fifty Russian-made Sukhoi Su-27 Flankers, the single most capable threat to the F-15 at this time. China is also developing two new fighters: the FC-1 and J-10. The FC-1, based on a single engine version of the Russian-built Mig-29 Fulcrum, is a lightweight “synergistic hybrid”—an aircraft that uses the best technology currently available on the world market.⁴ The J-10, China’s next generation fighter, is being developed with help from Israel and should enter production shortly after the turn of the century.⁵ Russia is also developing at least two new fighters. The first, the Su-35, is an upgraded version of the Su-27 and is expected to enter service around the turn of the century.⁶ The second fighter, designated S-32 and designed specifically for air superiority, made its first test flight in late September 1997. The S-32 is a truly new design that uses an all-composite airframe to lower its radar cross section and reduce the range where it can be detected by radar. It also uses the latest Russian jet engine technology, including thrust vectoring, as well as a forward swept wing, both of which greatly increase aircraft maneuverability.⁷ The date when the S-32 is expected to reach operational capability has not yet been determined; however, its existence does give reason for concern. According to Representative Curt Weldon (R., Pa.) “This is an indication that, while their conventional military is in total disarray, there are those in Russia that are willing to put dollars into leap-ahead technologies that could give them a significant capability five or 10 years down the road.”⁸

A RAND Corporation study, published in November 1995, identified three advanced multirole European fighters currently under development or in production. These fighters are France's Rafale, Sweden's Gripen, and the multinational EF-2000 Eurofighter. The study determined "...that these European aircraft will be highly competitive with existing U.S. fighters and future variants, will be fully developed and procured, and will be sold outside of Europe."⁹ All three designs use the latest technology and incorporate composite structures, relaxed stability with computerized flight controls, some degree of stealth, and advanced pilot displays.¹⁰ The RAND study also cites extensive computer simulations conducted by British Aerospace and the British Defense Research Agency which compared the effectiveness of the F-15C, Rafale, EF-2000, and F-22 against the Russian Su-35 armed with active radar missiles similar to the AIM-120 Advanced Medium Range Air-to-Air Missile (AMRAAM). The results were striking. The Rafale achieved a 1:1 kill ratio (1 Su-35 destroyed for each Rafale lost). The EF-2000 kill ratio was 4.5:1 while the F-22 achieved a ratio of 10:1. In stark contrast was the F-15C, losing 1.3 Eagles for each Su-35 destroyed.¹¹

While the Gripen is already in full production, the EF-2000 and Rafale will be operationally deployed at, or shortly after, the turn of the century. With all three fighters being aggressively promoted on the international market, the threat to U.S. air superiority is both substantial and real.

Advanced Active Air-to-Air Missiles

Advanced active air-to-air missiles, similar to the U.S. AIM-120 AMRAAM, will also threaten our ability to achieve air superiority in the future. Active radar missiles are initially cued by the launch aircraft. However, once they get close enough to their target,

they guide themselves using their onboard radar. This “launch and leave” capability allows the pilot of the launch aircraft to target other enemy aircraft or to defend himself if he feels targeted. These missiles, such as Britain’s Active Skyflash, France’s MICA, and Russia’s AA-12 Adder, can all be integrated onto existing and future aircraft. Upgrading current fighters with active missiles will significantly increase their air-to-air capabilities. Between 1995 and 2005, DIA estimates indicate the number of countries possessing advanced AMRAAM class missiles will increase from 11 to 25.¹² With advanced active air-to-air missiles proliferating, especially when combined with advanced fighters, the threat to U.S. air superiority gets even worse.

Advanced Surface-to-Air Missiles

Surface-to-air missile systems represent a totally separate threat to the air superiority effort. Advanced SAM systems are cheap compared to fighter aircraft, have demonstrated their effectiveness, and represent a quick and easy way for any country to upgrade its air defense capability.¹³ The Russian-made SA-10 and SA-12 are mobile Patriot class systems with multi-target engagement capability, firing long range, highly maneuverable missiles. In order to operate against these systems, all current conventional fighters will require a supporting force of aircraft armed with electronic jammers and high speed anti-radiation missiles (HARM) to provide suppression of enemy air defenses (SEAD).¹⁴ Advanced SAM proliferation is also on the rise. According to DIA, the number of countries with SA-10/12 class SAMs in 1985 was 4. By 1995, that number had risen to 14; with an increase to 22 expected by 2005.¹⁵ There should be little doubt that a country combining advanced SAMs with early warning and C² capabilities will pose a significant threat to our ability to achieve air superiority.

Summary

The proliferation of advanced weapon systems is on the rise. Unless significant modernization efforts are made, America will see its dominance of the air superiority arena deteriorate as we move into the 21st century. By then, the F-15 Eagle will be over twenty-five years old and will have seen its heyday as the world's premier air superiority fighter come to an end. New advanced fighters, armed with active air-to-air missiles, will have surpassed it in capability, while advanced SAM systems will make it increasingly difficult for all conventional fighters to operate in enemy airspace. The U.S. needs a new fighter to replace the aging F-15. The following chapter will explain how the F-22 Raptor will facilitate the overarching mission of air superiority well into the 21st century.

Notes

¹ Nick Cook, "Europe Competes With US Black Programs," *Interavia* 50 (July-August 1995): 41-44.

² Ibid.

³ Department of the Air Force, *F-22 Raptor...The Keystone of Air Dominance for the 21st Century* (Washington, D.C.: HQ USAF/XORFS, n.d.), 9.

⁴ Nick Cook, "Lifting the Veil on China's Fighters," *Jane's Defense Weekly* 25, no. 5 (31 January 1996): 52.

⁵ Ibid.

⁶ Department of the Air Force, *F-22 Raptor*, 8.

⁷ Michael D. Towle, "Russia Said to be Testing New Jet Fighter," *Philadelphia Inquirer* 27 October 1997.

⁸ Ibid.

⁹ Mark Lorell et al., "The Gray Threat," *Air Force Magazine* February 1996, 64-68.

¹⁰ Ibid.

¹¹ Ibid.

¹² Department of the Air Force, *F-22 Raptor*, 9.

¹³ Department of the Air Force, *F-22: A Revolution in Air Power*, white paper, February 1996.

¹⁴ Nick Cook, "Multi-role Fighters," *Jane's Defense Weekly* 8 May 1996, 23-29.

¹⁵ Department of the Air Force, *F-22 Raptor*, 7.

Chapter 4

F-22 Characteristics

Victory smiles upon those who anticipate the changes in the character of war, not upon those who wait to adapt themselves after the changes occur.

—Giulio Douhet

The F-22 Raptor is truly a revolutionary fighter aircraft, providing a quantum leap in capability over current conventional fighters. It incorporates the latest gains in stealth technology, aerodynamic design, engine performance, and integrated avionics to perform its primary mission of theater air superiority. These same characteristics also provide the JFC with an unequaled air-to-ground and SEAD capability in the total threat environment.¹ The following sections will discuss in greater detail the capabilities that will allow the F-22 to provide air dominance for the 21st century battlespace.

Stealth

Stealth technology will provide the F-22 with the same advantages enjoyed by the F-117 during the Gulf War—increased survivability and lethality by denying the enemy critical information required to successfully detect and attack it.² It is achieved, in part, through the internal carriage of all fuel and weapons. By reducing the F-22's radar cross section, stealth degrades the effectiveness of radar systems during the detection, track, and weapons employment phases of operations. Greatly shortened detection ranges

reduce the reaction time needed to effectively employ SAM systems against the F-22. In many cases, by the time enemy air defense operators realize the F-22 is there, it will be too late to engage before it's gone again. Stealth will also degrade the ability of radar-guided missiles to track the F-22 and fuse within lethal warhead distance.³ Stealth gives the F-22 one of its greatest advantages: a first look, first shot, first kill capability in all environments. The Raptor pilot will be able to detect, track, shoot, and kill his adversary before the enemy fighter can even detect the F-22's presence.⁴

Stealth effectively restores one of the key elements that flyers lost with the advent of radar—surprise; one of the key elements necessary for the successful employment of airpower. The Battle of Britain serves as an excellent example of the importance of surprise in air operations. If Britain had not been surrounded by a band of early warning radars that were integrated into a centralized C² system, the RAF's ability to intercept the attacking German formations before they reached their targets would have been greatly reduced. Surprise would have allowed the Luftwaffe to destroy more RAF fighters on the ground, increasing their own effectiveness and survivability. Considering how close the Luftwaffe came to breaking the RAF, it's almost a foregone conclusion that Germany would have won the battle, as well as changed the outcome of World War II, if they had possessed the element of surprise. Stealth technology directly supports the principle of surprise since it reduces an enemy's ability to detect the F-22 until it's too late to effectively counter it.

Supercruise

Supercruise describes the F-22's ability to fly at supersonic speeds without the use of afterburner. Conventional fighters must use afterburner to attain and sustain supersonic

speeds; a significant drawback since it results in extremely high fuel consumption.⁵ As a result, afterburner use is normally reserved for critical phases of flight such as threat reactions, maneuvering in an aerial dogfight, egressing a target area, etc. Therefore, conventional fighters spend the majority of their time at subsonic airspeeds.

Supercruise will provide five significant advantages to the F-22. First, it will greatly increase the F-22's operating range, or combat radius; allowing it to cover nearly three times the area of the F-15.⁶ Second, supercruise will greatly reduce the F-22's reaction time since it can travel to and from the fight at supersonic speeds to more rapidly range the battlespace. Third, supercruise will allow the F-22 to have much greater persistence over the battlefield; since getting to the fight won't require the use of afterburner, the F-22 will arrive on station with more fuel than it would if afterburner was required. Fourth, supercruise will limit enemy threat weapons effectiveness. Transiting through enemy airspace at supersonic airspeeds cuts enemy reaction time and shrinks the kinematic envelope of both air-to-air and surface-to-air missiles; in some cases, rendering them incapable of reaching the F-22 at all.⁷ Finally, in its ferry configuration loaded with four external fuel tanks, the F-22 will be able to deploy from one theater of operations to another with less tanker support than other fighters require, thus freeing up limited tanker assets for other missions.

Fuel is one of the biggest limiting factors for fighters. The Combined Bomber Offensive of World War II illustrates how this limitation can severely reduce the effectiveness of air power. After sustaining unacceptably high losses during two raids on German ball bearing plants at Schweinfurt in August and October 1943, the Army Air Corps was forced to temporarily halt long range daylight attacks on German targets that

were beyond the range of escort fighters.⁸ Not until the P-51 Mustang became available in sufficient numbers to achieve local air superiority in early 1944 were daylight bomber operations again launched in depth.⁹

The advanced engine technology that makes supercruise possible will enable the F-22 to range the battlespace farther and faster than any other fighter, allowing it to achieve Dominant Maneuver. This capability supports the principles of offensive, mass, and maneuver since it will allow Raptor pilots to take the initiative, concentrate ordnance when and where they choose, and force the enemy to be on guard against attack from everywhere at all times.

Integrated Avionics

The F-22 will feature the most advanced avionics suite of any fighter ever built. It takes full advantage of the product gained from the USAF's core competency of Information Superiority to provide the pilot with dominant battlefield awareness. The Raptor's avionics suite is characterized by very high speed integrated circuits, an integrated sensor design with common and easily replaceable modules, and fiber optics for rapid, high-volume data transfer. The brain of this sophisticated system, the common integrated processor, will deliver "the equivalent computing throughput of two Cray supercomputers."¹⁰ The F-22's modular avionics suite also allows for long-term upgrading and the infusion of new technology and systems as they become available.¹¹

The F-22 uses a number of new techniques and displays to provide superior situational awareness (SA) to the pilot. Unlike current fighters which have a number of dedicated displays to provide the pilot with information from the aircraft's various sensors, the F-22 will merge data from all sensors into a single display.¹² With the F-22,

the aircraft is the sensor integrator, unlike conventional fighters where that job falls on the pilot.¹³ This greatly reduces the pilot's workload, allowing him to spend more time studying the tactical situation and deciding how to deal with it, rather than having to figure out what the situation is in the first place. As an example, the F-15 pilot has three displays: radar, radar warning receiver (RWR), and data link. He has to determine if his radar contact is the same target being displayed from the Airborne Warning and Control System (AWACS) by his data link, and if so, is it also the same target his RWR is telling him has locked onto him.

At 203mm-square (8" x 8"), the F-22's primary display, the Tactical Situation Display (TSD), is large. It dwarfs the F-15's 5" x 5" (127mm x 127mm) data link and 4" x 4" (101mm x 101mm) radar displays, again making it easier for the Raptor pilot to visualize the picture in time and space. In the above example, the Raptor pilot would have the same radar, data link, and RWR information on his TSD. Although the F-22 does have three additional 152mm x 152mm (6" x 6") displays located to the left, right, and below the primary display, they provide expanded attack and defense detail to information already displayed on the TSD.¹⁴

Sensor fusion is another concept that maximizes the Raptor pilot's SA. Unlike current fighters which use separate processors for each onboard sensor, the F-22's central integrated processor combines the highest-quality data from all sensors to build the TSD picture. This eliminates having multiple track files on the same target.¹⁵ The F-22 doesn't have to rely on just its onboard sensors; information from a diverse array of offboard sources is also seamlessly fused into the TSD picture. Other capabilities include a sensor management system that automatically controls what each sensor does based on

the tactical situation, automatic emission control, which keeps electronic emissions to the lowest possible level, and automated target prioritization during multi-aircraft engagements.¹⁶

As already mentioned, the F-22's integrated avionics suite takes full advantage of Information Superiority. On the micro level, it also supports the principle of simplicity because it takes a large amount of data from a very complex environment and reduces it to the simplest picture possible, providing the pilot with dominate battlespace awareness.

Agility

Although it's designed to primarily engage enemy aircraft in the beyond visual range (BVR) arena, there will be times when the Raptor pilot has to get close to his work. Rules of engagement requiring visual identification prior to weapons employment, weapons failures, enemy countermeasures, or an undetected enemy fighter, could all force a turning dogfight.¹⁷ Combining an advanced airframe design; high output, thrust vectored engines; and a reduced stability, digital fly-by-wire flight control system, the F-22 is designed to out maneuver all current and projected fighter aircraft.¹⁸

Air-to-air combat in the visual arena is highly dynamic. Fighter pilots live and die by the maxim "Maneuver in relation to the bandit."¹⁹ In close quarter turning fights, the fighter with the best maneuverability will win. American fighter pilots in the Pacific Theater learned this lesson the hard way during the early days of World War II. There they encountered the Japanese Zero which was much more maneuverable than the Army Air Corps' P-40 Warhawk and Navy's F4F Wildcat fighters. The Zero achieved its high maneuverability by sacrificing armor protection for lighter weight; making it much more susceptible to destruction from even minor battle damage. Had the Zero possessed armor

protection comparable to contemporary American fighters while maintaining its superior maneuverability, the Japanese would most likely have been able to achieve air superiority in the Pacific. Had they done so, the outcomes of the Battles of Coral Sea and Midway may very well have turned out differently.

Versatility

The F-22 will provide the JFC one of his most versatile weapon systems, especially during the early halt phase of a conflict. Although it will be the world's premiere air superiority fighter, the F-22 will also have an inherent air-to-ground capability. Along with a reduced load of air-to-air ordnance, the F-22 will be capable of internally carrying two 1,000 pound Joint Direct Attack Munitions (JDAM). The JDAM is a precision guided weapon that uses its own inertial navigation system, with Global Positioning System updates, to provide 24 hour, all weather attack capability with accuracies of 10 meters or less.²⁰

During the Gulf War, F-15 pilots achieved air supremacy in just a few days. They did the job so well, in fact, they basically put themselves out of work; although F-15s flew throughout the war to ensure air supremacy was never threatened. Since the F-15 was designed strictly for air superiority, there was no other mission it could do, such as bombing Iraqi ground forces in Kuwait since F-15 squadrons had neither the suspension equipment necessary to carry bombs, nor the training needed to drop them. While its performance in the air should surpass that of the F-15 during Operation DESERT STORM, the F-22 will provide greater employment flexibility due to its air-to-ground capability. This versatility, coupled with supercruise and the ability to receive near real time target information, will allow the F-22 to range the battlespace quickly and put

virtually any enemy target at risk; a quality particularly well suited to dealing with such time critical targets as tactical ballistic missile (TBM) launchers. In the destructive SEAD role, stealth will allow the F-22 to penetrate and attack heavy enemy air defense systems with relative impunity.²¹ Once air superiority has been achieved, the F-22 will continue to support the principle of mass by helping to concentrate combat power at the decisive time and place through its Precision Engagement air-to-ground capability.

Increased Reliability and Maintainability

Reliability and maintainability were designed into the F-22 from the start. Ease of maintenance in the field and high reliability rates were required before each design element was considered complete. The F-22 will maintain higher mission capable rates while generating higher sortie rates than current fighters. It will do so with fewer support personnel and less maintenance equipment. Studies indicate that the F-22 will be able to fly 8.5 sorties before requiring major maintenance, compared to 5.4 sorties for the F-15. Increased reliability and maintainability will allow the USAF to generate more combat power with less logistical support and reduced life-cycle costs.²²

The F-22's increased reliability and maintainability will help the USAF accomplish the core competency of Agile Combat Support since F-22 support requirements will be less, and therefore easier to meet, than that of current fighters.

Reduced Airlift Support

F-22 squadrons will require 60% less airlift (5 versus 14 C-17s) and 40% fewer personnel to deploy than an F-15 squadron.²³ Reduced support requirements enhance the F-22's ability to support critical force projection capabilities. Enhanced deployability

will become increasingly important as our military moves away from overseas presence and relies more on power projection. It also directly supports the USAF core competency of Rapid Global Mobility.

The Synergistic Summary

As stated at the beginning of this chapter, the F-22 is truly a revolutionary fighter. The synergy of stealth, supercruise, and integrated avionics gives the F-22 a first look, first shot, first kill capability in all environments. Stealth and supercruise will allow the F-22 to operate in enemy airspace without the need for SEAD support. Integrated avionics will fuse data from all onboard, as well as, offboard sensors to take full advantage of information superiority and provide the Raptor pilot with the highest level of SA ever seen in a fighter aircraft. The F-22's advanced engine technology, aerodynamic design, and digital flight control system will give it unmatched maneuverability in the visual dogfight arena. Armed with two JDAMs, the F-22 will provide increased versatility over its predecessor, the F-15. Its air-to-ground capability, coupled with stealth, will allow the F-22 to put virtually any target within the battlespace at risk. Combined with near real time intelligence provided through its integrated avionics, the F-22 will also have a capability against time critical targets like TBM launchers that is superior to any current system. Improved reliability and maintainability will allow the F-22 to generate higher sortie rates than current fighters using fewer maintenance personnel. Enhanced deployability will allow F-22 squadrons to get to the fight with reduced airlift support, freeing up critical transport assets for other tasks.

All of these synergistic strengths will be critically important during any future conflict. The 1997 *Military Strategy of the United States of America* highlights the need

for U.S. forces to be able to “...rapidly defeat initial enemy advances short of their objectives...” and goes on to assert that “Failure to halt an enemy invasion rapidly would make the subsequent campaign to evict enemy forces from captured territory much more difficult, lengthy, and costly.”²⁴ In a crisis situation, F-22s from the continental U.S. could arrive on scene anywhere in the world in a matter of hours, possibly deterring any further aggression. This advanced guard would arrive with sufficient precision firepower to destroy key enemy warfighting capabilities, disrupt enemy air raids while they’re still over enemy territory, forcing the enemy on the defensive, and denying the enemy any airborne reconnaissance capability. F-22s would provide local air superiority in order for high value airborne assets such as AWACS, Joint Stars, Rivet Joint, and the Airborne Laser to begin operations, and to protect airfields and ports for airlift and sealift bringing forces into the theater. The F-22 would also give the JFC the option of conducting precision air-to-ground strikes from day one if required.²⁵

If the F-22 is so great, then why does the question of whether or not to buy it still remain? In this case, as in most others, the answer is money. The next chapter will look at the cost of procuring the F-22, as well as possible alternatives for a different system.

Notes

¹ Maj O’Connell, F-22 Mission Capabilities, point paper, 1 April 1997.

² Ibid.

³ Department of the Air Force, F-22: A Revolution in Air Power, white paper, February 1996.

⁴ Department of the Air Force, *F-22 Raptor...The Keystone of Air Dominance for the 21st Century* (Washington, D.C.: HQ USAF/XORFS, n.d.), 10.

⁵ Department of the Air Force, F-22: A Revolution in Air Power.

⁶ Department of the Air Force, *F-22 Raptor*, 11.

⁷ Ibid.

⁸ The United States Strategic Bombing Survey, *Summary Report (European War)* (Maxwell AFB, Ala.: Air University Press, October 1987), 15.

⁹ Ibid, 16.

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¹⁰ Robert K. Ackerman, "Low-Observable Techniques Rest on Avionics Integration," *Signal* 50, no. 7 (March 1996): 47-49.

¹¹ Department of the Air Force, F-22: A Revolution in Air Power.

¹² Stacey Evers, "Data Fusion Gives F-22 Pilots the Big Picture," *Jane's Defense Weekly* 26, no. 2 (10 July 1996): 41.

¹³ Department of the Air Force, *F-22 Raptor*, 11.

¹⁴ Bill Sweetman, "F-22 Stealth Fighter Takes Aim at Export Market," *Interavia* 50, no. 594 (October 1995): 48-50.

¹⁵ Ibid.

¹⁶ Ibid.

¹⁷ Department of the Air Force, F-22: A Revolution in Air Power.

¹⁸ Maj Chester Nowak, F-22 Advanced Tactical Fighter, bullet background paper, 21 April 1997.

¹⁹ One of many fighter pilot one-liners that describe basic truths in the air-to-air arena. Examples include "*Up is bad*," "*Lose sight, lose fight*," and "*Nose position versus energy*" among others.

²⁰ Maj O'Connell, F-22 Mission Capabilities.

²¹ Ibid.

²² Department of the Air Force, F-22: A Revolution in Air Power.

²³ Department of the Air Force, *F-22 Raptor*, 16.

²⁴ Department of the Chairman, Joint Chiefs of Staff, *National Military Strategy of the United States of America* (Washington, D.C.: Government Printing Office, 1997), 16.

²⁵ Maj O'Connell, F-22 is a Revolutionary Joint Asset, point paper, 29 February 1996.

Chapter 5

Alternatives and Analysis

Airpower is like poker. A second-best hand is like none at all—it will cost you dough and win you nothing.

—General George Kenney

In fiscal year 2004 dollars, the unit flyaway cost for the F-22 is \$102 million, roughly three and a half times the cost of buying the F-15.¹ With the U.S. military downsizing and defense budgets shrinking, many opponents of the F-22 desire a less expensive replacement for the F-15. The following sections will explore three popular alternatives to buying the F-22 and will analyze the validity of each.

Option One—F-15 “X”

One alternative to buying the F-22 is to develop and buy an improved version of the F-15C, which would be procured along the same timeline as the F-22 to minimize budgetary ripples. This upgraded F-15 “X” would take advantage of capabilities like integrated avionics and sensor fusion currently planned for the F-22. Stealth and new engine technology should be transferable to the F-15 “X” as well. However, without totally redesigning the airframe, there’s only so much stealth capability that can be added on to the current Eagle design.

In 1990, the Department of Defense conducted the Major Aircraft Review (MAR), in which extensive F-15 upgrades were examined to determine their suitability for fulfilling the future air superiority role in lieu of the F-22.² The MAR found that an F-15 derivative would cost \$41 billion to develop and procure. Since F-22 research and development costs are basically water under the bridge (i.e. not recoverable), the remaining cost to procure the F-22 is \$44 billion. The MAR also determined that the F-15 derivative would only provide 31 percent of the combat effectiveness of the F-22. Therefore, the F-15 “X” equates to roughly one third the effectiveness of the F-22 at 90 percent of the cost.³ Stated from the opposite perspective, the F-22 provides a 70 percent increase in combat capability over the F-15 “X” for only 10 percent more money—a fact that totally destroys the notion that it costs 100 percent more to go first class.

In a second study conducted in the spring of 1991, the Air Force concluded that while an advanced F-15 derivative would cost less to initially buy, it would also be more expensive to maintain and operate than the F-22.⁴ Finally, a more recent Air Force study concluded that by 2008, in the most demanding scenario, F-15 losses are expected to be 20 times greater than those of the F-22.⁵ Even if the study is only half accurate, the USAF cannot afford those kinds of losses if it’s to help gain air superiority for the JFC.

Option Two—Joint Strike Fighter

A second alternative to the F-22 is the Joint Strike Fighter (JSF), which is a single engine, single seat, stealthy replacement for the USAF F-16 and F-15E, and the Navy/USMC F/A-18 and AV-8B. Proponents argue that stealth will allow the JSF to evade enemy fighters, thus eliminating the need to shoot them down in the first place. At less than one third the cost of the F-22, the JSF would save the American taxpayers

roughly \$24 billion. At first glance the JSF option might sound good; however, after more in-depth analysis a number of shortcomings become evident.

First, the JSF is designed for the air-to-ground mission. Although it will most likely carry air-to-air ordnance for self protection, the JSF will not be suited to hunting down and destroying the enemy in the air. If the JSF was the only type of aircraft conducting air operations, then evading enemy fighters might be an option. However, until we achieved an all JSF force, there would be other types of non-stealthy aircraft that could not evade determined enemy fighters when conducting offensive operations. This would be especially true when conducting combined or coalition operations. The JSF would also be unsuitable for conducting defensive counterair operations since this is purely an air-to-air mission.

The second problem with the JSF option is the operational deployment timeline. The JSF, whose design is still in competition between two primary contractor candidates, is not planned to be operational until 2010. By that time, the F-15 Eagle would be 35 years old. Even assuming the JSF would be a more capable air superiority platform than the F-15, a speculative assumption at best, the JSF alternative totally begs the question of how the U.S. will guarantee air superiority for its forces at a time when the F-15 is at a distinct disadvantage to fighters like the Su-35, Rafale, and EF-2000. Under this scenario, the U.S. ability to achieve air superiority will be compromised for at least five years longer than if the USAF buys and deploys the F-22 by 2004 as currently scheduled.

Although the JSF should provide a follow-on air-to-ground capability superior to all current strike fighters, it was never intended, and never will be, a suitable substitute for the F-22.

Option Three—Fewer F-22s

The third and final alternative is to simply buy fewer F-22s than originally planned. This option has actually been forced upon the Air Force twice already. In 1974, when the Air Force began the process of developing the Advanced Tactical Fighter as the F-15's eventual successor, it envisioned a one for one replacement ratio (750 F-22s).⁶ After the collapse of the Soviet Union and the accompanying drawdown of U.S. military forces, the 1993 Bottom-Up Review drove the F-22 buy down to 438 aircraft.⁷ Finally, with the 1997 Quadrennial Defense Review reducing the USAF to 12 fighter wing equivalents, the F-22 buy was further reduced to 339 total aircraft.⁸ This latest number represents roughly three fighter wing equivalents, or 25 percent of the total USAF fighter force; a rather strong indication of the importance the Air Force places on air superiority.

Option three would suggest only buying a small number of F-22s, maybe one wing equivalent, to help beef up the F-15 fleet. According to General Richard E. Hawley, commander of Air Combat Command (ACC), this represents a “silver bullet” approach. He further states, “that’s not enough to do the job on anybody’s calculator.”⁹

Buying fewer than 339 F-22s will put the USAF's ability to support the strategy of fighting two simultaneous Major Theater Wars (MTW) at risk. After subtracting from one wing equivalent (three squadrons) the aircraft needed to man the USAF Weapons School, the 422d Test and Evaluation Squadron, and the Fighter Training Unit where pilots would learn to fly the Raptor, there would be roughly one squadron of F-22s to fight in each MTW. Although option three would be the lesser of three evils, it still doesn't qualify as a valid alternative to procuring a full buy of 339 F-22s.

Counterstealth Concerns

Since stealth is one of the F-22's strong suits, it's only fair that stealth countermeasures be addressed when analyzing the F-22's overall capabilities. While there are some ground based radars that can detect stealthy aircraft, their detection ranges are currently short. These systems include very high frequency waveband radar, bistatic radar which uses non-collocated transmitters and receivers, ultra-wideband radar, and over-the-horizon radar.¹⁰ Although some of these systems may be capable of detecting stealthy aircraft, detection is not an end in itself. Effective air defense combines three interrelated functions: detection, guidance, and kill. In order to achieve a 50 percent probability of kill, each function must be carried out with an 80 percent or higher probability of success.¹¹ While detecting a stealthy fighter is one thing, guiding a surface-to-air missile to an intercept within fuzing distance and lethal warhead radius is quite another. Additionally, none of the radars listed above are suitable for employment onboard aircraft, especially fighters.

While it's reasonable to expect stealth technology to be overcome in time, there are at least three reasons why this won't render the F-22 ineffective. First, it will be very costly to develop air defense systems capable of easily detecting and destroying stealthy aircraft. The price tag alone will put counterstealth systems out of reach for many potential adversaries. Second, supercruise will allow the F-22 to transit through the weapons engagement zone of enemy air defense systems quickly, thus shrinking the kinematic envelope and reducing the effectiveness of all SAMs. Third, the F-22's integrated avionics suite, using inputs from both on and offboard sensors, will detect, identify, and locate threat radars, allowing the Raptor pilot to maneuver as required to

avoid or minimize detection and engagement. While its capabilities, especially against SAM systems, may be degraded by counterstealth technology, the F-22 will still retain a first look, first shot, first kill capability against all projected future fighter threats.

Simulation Comparisons

In an effort to quantify the F-22's capabilities, the Air Staff conducted a computer study in 1997 using the Cray-based Extended Air Defense Simulator (EADSIM). This study compared the results from two strike missions against a selected target in a notional country with an advanced IADS in the 2010 timeframe. The first mission employed Enhanced Conventional Fighters (ECF), which were armed with the Joint Standoff Weapon (JSOW). The ECF is a notional fighter very similar to both the F-15 "X" discussed above and to the Navy's newest fighter, the F/A-18E Super Hornet. The second mission employed the F-22 armed with JDAM. Both missions assumed it was day one of the war with enemy air defense forces at full strength. Each mission was force sized to ensure 100 percent success.

The first mission required 66 ECF aircraft, 4 EA-6B Prowlers for SEAD support, and 72 Tomahawk Land-Air Missiles. When counting support aircraft, such as tankers, the total value of all assets at risk for the mission was \$4.8 Billion. Thirty ECF aircraft were lost during the mission to the enemy IADS.¹²

By comparison, the F-22 mission required 20 F-22s and 16 Conventional Air-Launched Cruise Missiles. Again including support aircraft, the total value of all assets at risk for the mission was \$1.4 Billion. When counting battle damage, only 1.7 F-22s were lost during the mission.¹³

The EADSIM study showed that the F-22, with its true stealth capability, is a much more cost effective weapon system than a conventional fighter with pseudo-stealth characteristics. The F-22 accomplished the same level of mission success with less than one third the aircraft and less than one fourth the aircrews as the ECF. The total value of all assets at risk in the F-22 mission was less than 30 percent of the total value of all assets required for the ECF mission. Finally, F-22 losses were less than 10 percent of ECF losses.¹⁴ F-22 and ECF comparisons are depicted in Figures 1 and 2.

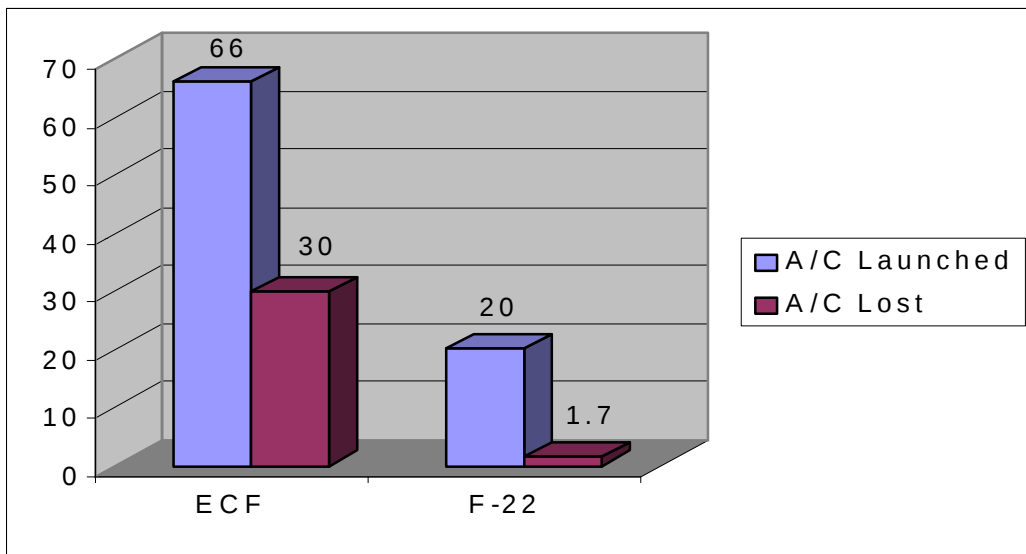


Figure 1. Comparison of ECF and F-22 Aircraft Required and Lost.

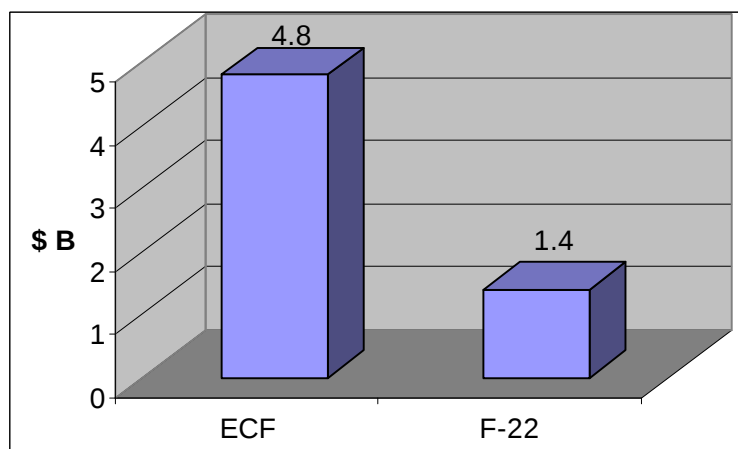


Figure 2. Dollar Value of Assets at Risk in Billions.

Summary

Although there are a number of alternatives available that will cost less money than the F-22, none of them are as cost effective in the long run as buying the currently planned full compliment of 339 Raptors. No other aircraft will have its ability to provide air dominance in the 21st century. Perhaps the reason why the USAF needs the F-22 is best summed up by General John Michael Loh, former ACC commander:

Air superiority is not an optional mission. It's not the kind of mission where you want to take a chance on only winning 100 to ninety-nine in double overtime. It's a mission you want to win 100 to zero; slam-dunk, do it efficiently and effectively, and with few casualties.¹⁵

Notes

¹ Maj Chester Nowak, F-22 Advanced Tactical Fighter, bullet background paper, 21 April 1997.

² Department of the Air Force, F-22: A Revolution in Air Power, white paper, February 1996.

³ Department of the Air Force, *F-22 Raptor...The Keystone of Air Dominance for the 21st Century* (Washington, D.C.: HQ USAF/XORFS, n.d.), 15.

⁴ Department of the Air Force, F-22: A Revolution in Air Power.

⁵ Ibid.

⁶ John A. Tirpak, "Who Needs the F-22?" *Air Force Magazine* 78, no. 4 (April 1995): 26-29.

⁷ Ibid.

⁸ Department of Defense, *Report of the Quadrennial Defense Review* (Washington, D.C.: Office of the Secretary of Defense, May 1997), vii.

⁹ Tirpak.

¹⁰ Bill Sweetman, "A Needle in the Haystack: Assessing Stealth Countermeasures," *International Defense Review* 27, no. 3 (March 1994): 38-40.

¹¹ Ibid.

¹² Briefing, SAF/AQL, subject: Comparison of F-22 and Enhanced Conventional Fighter (ECF) Employment, 1997.

¹³ Ibid.

¹⁴ Ibid.

¹⁵ Tirpak.

Chapter 6

Conclusions

Achieving air superiority will be an absolute necessity in order to win on the modern battlefield of tomorrow. It is the enabling capability that will allow joint forces the freedom to attack while enjoying freedom from attack; a prerequisite that must be achieved prior to successfully conducting all other operations. Air superiority is also zero-sum: if one side has it, the other side doesn't!

The U.S. has placed great importance on ensuring its ability to gain air superiority in the past. As a result, no U.S. ground troops have been killed by enemy aircraft in well over 40 years.¹ The USAF's F-15 Eagle was designed specifically, and exclusively, for the air superiority mission and holds the title as the premiere air superiority fighter in the world today. However, the F-15 will be 25 years old by the turn of the century and will lose its preeminence to newer, more advanced fighter designs by that time. Advanced SAM systems will also make it very difficult for all conventional fighters to operate over enemy territory without large SEAD support packages. Unless modernization efforts continue, the U.S. ability to guarantee air superiority will diminish significantly.

The F-22 Raptor is the guarantor of America's air superiority dominance in the 21st century. Its characteristics of stealth, supercruise, agility, and integrated avionics will give it the undisputed edge in the air-to-air arena against any current or planned future

threat. The same characteristics will also allow it to operate alone in a heavy air defense environment over enemy airspace. The F-22's inherent precision air-to-ground capability will allow it to threaten virtually any target within the battlespace, including time critical targets such as TBM launchers. Increased reliability and maintainability will allow the F-22 to generate higher sortie rates than the F-15, while its reduced airlift requirements will allow F-22 squadrons to deploy with less than half the airlift support as well. Although cheaper alternatives to the F-22 do exist, none of them come close in capability.

In its report, *Transforming Defense—National Security in the 21st Century*, the National Defense Panel concluded:

The types of missions our military and related security structures will be required to perform in 2010-2020 remain largely unchanged....We must be able to project military power and conduct combat operations into areas where we may not have forward-deployed forces or forward bases. In particular, we must have the ability to put capable, agile, and highly effective shore-based land and air forces in place with a vastly decreased logistics footprint.²

Whether the panel members realized it or not, they were encapsulating the major strengths and capabilities of the F-22 Raptor.

The F-22 will be the cornerstone of the U.S. air superiority force in the 21st century. It contributes directly to, or takes full advantage of, all six Air Force core competencies and all four operational concepts of *Joint Vision 2010*. When stating his position on the importance of air dominance in the future, former Secretary of Defense William J. Perry said:

We are not looking for a fair fight. If we get into a fight with someone, we want it to be unfair. We want the advantage to be wholly and completely on our side.³

The F-22 Raptor is the revolutionary fighter that will guarantee America a very unfair advantage in any future conflict.

Notes

¹ Department of the Air Force, F-22: A Revolution in Air Power, white paper, February 1996.

² National Defense Panel, *Transforming Defense – National Security in the 21st Century* (Washington, D.C.: Government Printing Office, 1 December 1997), ii.

³ Robert Dudney, “The Air Dominance Budget,” *Air Force Magazine* 79, no. 5 (May 1996): 16-19.

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