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The Future of the Fighter Pilot... Will There Be a 6th Generation Fighter?

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—Jason A. Purdy

EXECUTIVE SUMMARY

Title: The Future of the Fighter Pilot...Will There Be a 6th Generation Fighter?

Author: Major Jason A. Purdy, United States Air Force

Thesis: The United States Air Force faces the difficult task of modernizing its fleet of aircraft during a time of shrinking military spending and increasing development costs of weapon systems. The Air Force must determine what it requires from a 6th Generation Fighter Aircraft and if it is both financially and technologically possible to achieve by 2030.

Discussion: History demonstrates the research, development and production of aircraft grows significantly with each new generation of equipment. The United States military sees this culminate in the F-35 as costs grow exponentially and the timeline slips by years. Additionally, current budget issues require the military to explore methods of developing and incorporating new technologies in the cheapest manner possible. This leads to increased difficulty in both determining what is technologically feasible in a next generation aircraft, what is required in that same aircraft, and how industry can provide the product both on time and on budget. With current timelines for the retirement of today's fighter aircraft, the Air Force plans to field a new aircraft by 2030 to alleviate its aging aircraft issue as well as to counter anticipated anti-access area denial technologies fielded by potential adversaries.

Conclusion: Given current and foreseeable budget constraints and potential requirement development and mission creep, the Air Force will not field a true 6th Generation Fighter aircraft by 2030. However, it must field a 5+ Generation Fighter in order to meet the requirements of national defense. This aircraft will fill a role very similar to the F-16 which provided a technological step between the F-4 and F-35 but not a true leap forward. The Air Force has begun work on this aircraft but must move rapidly in order to meet the timeline and fulfill its obligation to defend the nation.

Introduction

On 1 April 1915, the French pilot Roland Garros flew his Morane-Saulneir L airplane and shot down the first enemy aircraft using a forward firing machine gun operated by the pilot.¹ With that, the fighter aircraft was born and the race to achieve air superiority had begun. The end of the War to end all wars failed to stop nations from working to achieve the fastest, most agile, and best armed aircraft. With the start of World War II, the United States found itself in the midst of developing one of the most important air domination weapons of the war in the P-51 Mustang. The F-86 (Korean War), the F-4 (Vietnam), the F-16, and now the F-35 are the air domination successors to the P-51. This paper examines the evolution of multi-role aircraft from the P-51 through the F-35. Each generation shares a remarkably similar trajectory in increases in technology, complexity and, as a result, cost. Projections for the F-35 suggest that the United States Air Force cannot afford a 6th Generation fighter aircraft. This paper will explore how the USAF should prepare for the post budget situation while at the same time as keeping its air superiority edge. The question it intends to research is: why will the Air Force not develop, produce, and field a 6th generation fighter aircraft by the year 2030?

USAF Aircraft through History

Throughout its short history, the United States Air Force operated weapon systems viewed as the workhorses of the fleet. These aircraft normally contained a multi-role capability, allowing them to perform both air-to-air and air-to-ground missions, and their lifespans varied from just a few years in the early Air Force to spanning decades for the most recent aircraft. Each generation fielded a new capability that separated it from its predecessor. These capability advances include the first jet engine as the Air Force transitioned from the P-51 to the F-86 or the internal radar in the F-4. Additionally, with each new technology came the associated increase

in aircraft complexity which resulted in the cost of research, development, and production often increasing. I intend to look at the first four workhorses of the Air Force starting with one of the greatest fighter aircraft the world has known. These aircraft illustrate the history of the Air Force's development of multi-role fighters and show the evolution of capability across the spectrum of air warfare.

North American P-51 Mustang

The P-51 Mustang proved itself one of the most innovative fighter aircraft of World War II. The fact the P-51 went from a handshake agreement to prototype in less than 120 days adds to its impressive history.² Its designers introduced a new, laminar flow wing design which greatly improved performance. When the new airframe received several improvements to include a tear drop canopy and the Packard Merlin V-1650-7 engine, producing nearly 1,700 horsepower, the P-51D was born.³ This Mustang defined air domination in the European theater of World War II after it entered service in 1944. It outperformed all German aircraft and, despite there being more American P-47s and greater than twice as many British Supermarine Spitfires produced, recorded more enemy kills, 4,950, than any other Allied aircraft.⁴ It continued to operate through the Korean War and remained in the fleet of the Air National Guard and Reserve units until 1957. The P-51 set the standard for future air dominance by the United States Air Force. One of the most startling aspects of the P-51 is the price tag. The original cost of each aircraft was only \$51,000 in 1944 which equates to approximately \$655,500 in 2011 dollars.⁵ This means that the entire P-51D fleet of 7,954 aircraft came at a 2011 price tag of \$5.2B, pretty impressive for the dominant air superiority fighter of World War II. This can be compared to the recent Department of Defense (DoD) contract with Lockheed Martin to produce 30 F-35 aircraft (21 conventional F-35A fighters, three F-35B STOVL aircraft, and six F-35C carrier fighters) for

approximately \$4B.⁶ While the F-35 is obviously a much more capable aircraft than the P-51, this capability comes with an exponential price increase even when comparing same year dollars.

North American F-86 Sabre

North American, the same company responsible for the P-51, began development of the F-86 in 1945. The decision and requirement to develop this next generation came about due to the rapidly advancing technologies being incorporated into aircraft, specifically, the jet engine. The Sabre became the first American fighter aircraft to incorporate jet propulsion, swept wings and a radar assisted gun sight. The F-86A-5 utilized an engine which produced approximately 5,200 lbs of thrust and a top speed of 685 mph.⁷ The aircraft first arrived in Korea on 13 December 1950 and quickly established a reputation as a “MIG Killer” by setting an 8:1 kill ratio.⁸ Over the course of the Korean War, the F-86A, E and F raised the standard set by the P-51 Mustang. It accounted for the shoot down of 792 enemy MIG-15s.⁹ North American built over 5,100 Air Force F-86s with production spanning from 1949 until 1956, making it the largest production jet fighter aircraft in the history of the Air Force.¹⁰ The first F-86 entered service in 1950 and different variants served in the active duty or Air National Guard for the next 20 years before retirement in the fall of 1970.¹¹ With the increase in technology and capability came a corresponding increase in overall cost of the aircraft. The average price of an F-86A was \$178,000 in 1950, about 3 times the cost of a P-51D just 6 years earlier. This translates to approximately \$1.67M in 2011 dollars.¹² Within one generation of aircraft, the Air Force witnessed cost growth based on increased technologies and capabilities. However, this increased performance also ensured the previous generation of aircraft, all propeller driven fighters, were completely obsolete on the field of battle.

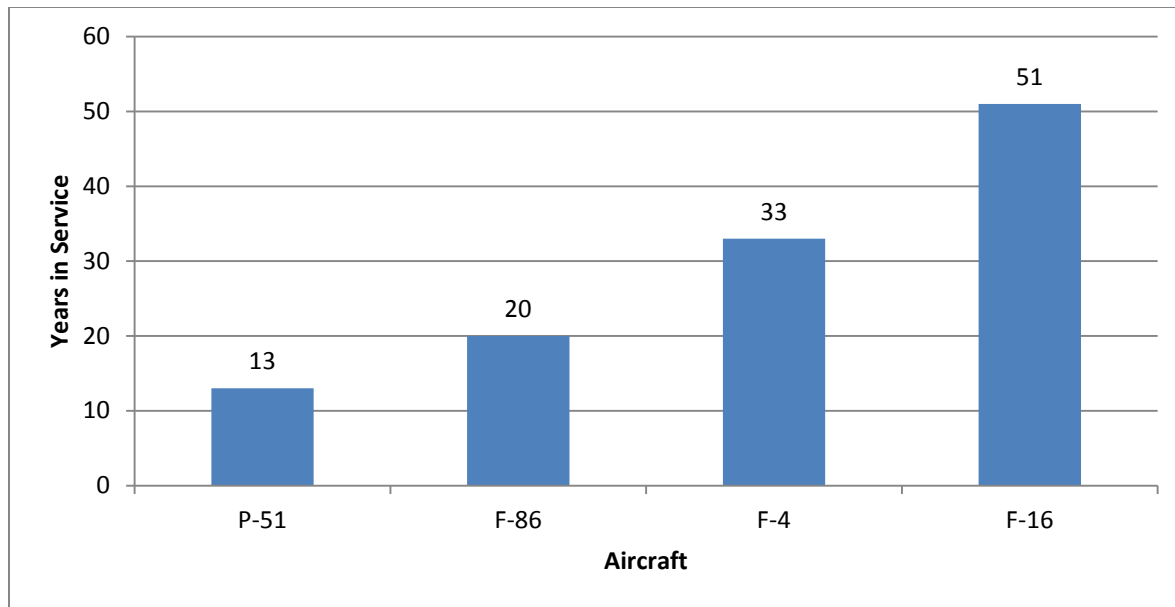


Fig 1. Aircraft Types and Number of Years in USAF Service
Note: F-16 Service Life Notional Based on Projected 2030 Retirement

McDonnell Douglas F-4 Phantom II

The United States Air Force utilized a large number of aircraft throughout the 1950s and 1960s. However, the primary fighter aircraft to enter the arsenal in numbers equating to the replacement of the F-86 was the F-4E Phantom II. The development of the F-4 began in 1954 as a project for the United States Navy. Much like the F-86, the military required a new fighter aircraft to keep pace with the Soviet Union in the technological race. More powerful engines, new weapon capabilities like the air-to-air missile, and systems like the internal radar required a new platform to allow the incorporation of these advancements. As development continued, the Navy and Marine Corps received F-4 variants before the Air Force began testing and finally chose the F-4 as its new primary fighter aircraft. The Air Force received its first F-4C in 1963 and began receiving the F-4E in 1967.¹³ The F-4 contained numerous upgrades when compared to the F-86. First, it utilized two afterburning engines making the aircraft capable of flying at speeds greater than Mach 2. Second, the F-4 operated an internal radar system allowing it to fire

air-to-air Sparrow missiles. Finally, it contained numerous countermeasures to the enemies increased air-to-air and surface-to-air defenses allowing the F-4 to continue to operate in increasingly dangerous environments. The Air Force purchased more than 2,600 F-4s and it served over 30 years until the final one retired from service in 1996.¹⁴ The F-4 was the first Air Force fighter to take part in two wars separated by more than a decade. It was the lead air dominance and ground attack aircraft during Vietnam and remained viable in the Suppression of Enemy Air Defenses role during the Gulf War. The F-4 proved itself one of the most versatile aircraft in the history of the Air Force. It also came at an average unit cost of approximately \$18.4M in 1965 dollars.¹⁵ This equates to an astounding \$132.1M in 2011 dollars!¹⁶ The Air Force saw the cost of a frontline fighter explode in just over a decade. However, like the F-86, the F-4 made many other multi-role aircraft within the service obsolete. Its capabilities allowed it to become the primary fighter within the Air Force for nearly two decades while the development and procurement of the next era of aircraft occurred.

Lockheed Martin F-16 Fighting Falcon

The design process for the F-16 began in 1972 as part of the Air Force's Lightweight Fighter Program. The Air Force planned to learn from the experiences in Vietnam which showed that the F-4 was vulnerable against lighter, more agile opponents. The Service chose the F-16 as its next multi-role aircraft in 1976 and received the first operational F-16A in 1979. The final, common configuration became the F-16C/D which began introduction in 1981.¹⁷ Much like its predecessors, the F-16 incorporated emerging technologies. Besides improved radar and avionics, the F-16 utilized a cutting edge fly-by-wire system. For the first time, the pilot did not directly move the flight controls via a hydraulic system. Instead, the pilot made inputs that a computer interpreted and then moved the control surfaces accordingly. This multiple computer

system allowed the F-16 to both fly at high angles of attack as well as remain maneuverable at slow speeds.¹⁸ The F-16 also demonstrated itself as one of the most multi-functional aircraft in the inventory. The F-16 carries nearly every weapon in the arsenal from air-to-surface laser and global positioning system guided smart bombs, dumb bombs, air-to-surface and anti-radiation missiles, air-to-air missiles, and nuclear weapons. This capability made the F-16 a workhorse of the arsenal. Since then, the F-16 participated in every major Air Force combat action over the past 30+ years. Originally scheduled for retirement by 2006, the Air Force continues upgrading the avionics and structural components for this aircraft to potentially continue operations beyond 2020.¹⁹ One important aspect of the F-16 came in its very low per unit cost. Based on 1998 dollars, the F-16 was only \$18.8M per copy.²⁰ This translates to approximately \$26.1M in 2011 dollars. This breaks the trend in aircraft procurement. From the P-51 through the F-4, the procurement prices increased exponentially. However, the unit cost for an F-16 in 1979 was only approximately 20% that of an F-4 in 1965. The Air Force's efforts to learn from the F-4 apparently paid off both in production and in the budget.

The Near Future: F-35

The F-35 is the most expensive program in the history of not just the USAF but the entire DoD. Furthermore, as the F-35 comes online, its detractors argue the US military remains so far ahead of its potential adversaries in combat capability; the aircraft is not a current requirement. The F-35 program will be another example of a military program failing come in on time and on budget.

From the early 1980s through the mid-1990s, the United States Air Force, Navy and Marines began research and development on a number of different programs to produce new fighter aircraft capabilities. The requirement for a new aircraft grew from multiple factors. First,

the military anticipated current airframes like the F-16 to last approximately 8,000 flying hours. This meant that the expected 10 – 15 year development and production timeline provided a new aircraft as the old were ready to retire. Second, advances in both offensive and defensive technology, stealth and enemy air defenses, made a new airframe appear to be a requirement in the anticipated timeline.

The military utilized a wide variety of programs to include: the Defense Advanced Research Projects Agency's Advanced Short Take-Off/Vertical Landing (ASTOVL) program from 1983-1994, the Air Force's Multi-Role Fighter (MRF) from 1990-1993, the Navy's Advanced Tactical Aircraft (ATA) from 1983-1991, the Naval Advanced Tactical Fighter (NATF) from 1990-1991, and the Joint effort in the Advanced-Attack/Advanced/Fighter-Attack (A-X/A/F-X) from 1992-1993.²¹ The majority of these programs ended as a result of budget cuts, cost overruns, or other related issues. The Services could not avoid the requirement for long-term replacements for the current fleet of combat aircraft. In the case of the Air Force, the F-16 was the first requiring replacement.

Following these programs and as the result of a four year competition, on 26 October 2001 the Department of Defense chose Lockheed Martin as the lead to develop the Joint Strike Fighter (JSF). For the first time in the history of the United States military, the DoD decided to design an aircraft to meet the requirements of the Air Force, Navy and Marines from the outset. While the F-4 had been utilized by all three services during and after Vietnam, the platform started as a Navy program. Additionally, from the start of the JSF, nine partner nations signed on to contribute to the research, development, and budget with the intent of purchasing the JSF to replace aircraft within their aging fleets.²² The concept of spreading R&D risk in this manner at the same time as pre-signing a wide number of future customers was designed to lower unit cost.

The Services anticipate the F-35 bringing a new level of combat capability and survivability to the battle space. The aircraft integrates numerous new technologies in its radar system, cockpit management, and systems integration.²³ Furthermore, it provides a stealth capability allowing it to survive in the anti-access area denial environment that continues to become more prevalent as defensive countermeasures continue to decrease in price.

From the beginning, the Pentagon stated the JSF program “was structured from the beginning to be a model of acquisition reform, with an emphasis on jointness, technology maturation and concept demonstrations, and early cost and performance trades integral to the weapon system requirements definition process.”²⁴ F-35 development focused on four “program pillars” which intended the F-35 to be affordable, lethal, survivable, and supportable.²⁵ However, the program’s primary emphasis is the affordability of the development, production and life-cycle support of the aircraft.²⁶ In working towards making the aircraft affordable, the development team strove to develop common parts across the variants. They also created the Autonomic Logistics system which is designed to reduce the life cycle cost of the aircraft by monitoring system performance and transmitting that information to maintenance crews in the effort to keep overall system costs within estimates.²⁷ Another goal included the utilization of off-the-shelf equipment for inclusion into the aircraft systems. This is intended to reduce aircraft specific design and production costs throughout the airframe. Finally, the JSF team anticipated capitalizing on lessons learned about stealth technology from the Air Force’s F-22 Raptor in further efforts to keep the price tag within the desired range. Unfortunately, many of these efforts failed. In fact many of the issues caused an actual increase in cost. Hardware development issues, software maturity, incorrect testing timelines, and production difficulties all

added to the cost despite the innovative approach adopted by the US and its allied partners in the acquisition cycle.

According to a Government Accounting Office report released in May 2011, the initial program cost estimate to the DoD in October 2001 showed \$233B (baseline 2002 \$) for research, development and the procurement of 2,866 aircraft for the US military. This also represented full-rate production beginning in 2012. In 2007, following development issues, cost overruns and timetable slips, the government set a new baseline of \$278.5B (baseline 2002 \$) for a reduced procurement of 2,458 aircraft and full-rate production slipping to 2013. These numbers changed again in 2010 when the Pentagon provided a new program cost estimate of \$382.5B (baseline 2002 \$) for 2,457 aircraft.²⁸ Not only had the program cost increased by over \$100B, but the new estimate planned for full-rate production to occur in 2016. In just 9 years, the most expensive program in the history of the DoD grew by nearly \$150B and slipped by at least 4 years.

The overall program cost increases significantly impacted the per aircraft price tags. In 2001, the DoD provided an initial cost estimate of approximately \$50.2M per aircraft (baseline 2002 \$). In 2007, the Pentagon provided a revised estimate of \$69.2M per copy (baseline 2002 \$).²⁹ By March 2010, the estimated fly-away cost of each F-35 aircraft increased to \$80-95M (baseline 2002 \$).³⁰ These cost increases not only impact the number of aircraft the United States Air Force and other services can afford to purchase, it has also prompted the foreign partners to question their investment and reconsider their collaboration.

Many of the partner nations originally entered the program with the same expectations as the United States; they wanted a fifth generation, stealth aircraft with a low procurement and life cycle cost. While Japan recently agreed to purchase 42 aircraft at an estimated cost of more than

\$7B³¹, other nations to include the United Kingdom, Australia, Canada, and Israel grow more concerned with each new report released concerning budget expansion and schedule slips. Additionally, their concerns extend beyond just the growing price tag and timeline. It also stems from the expected difficulty, price tag and timetable associated with integrating nation specific weapons.³² The UK and Israel, specifically, continue to express growing concern. The UK witnessed a similar integration problem occur during their recent C-130J purchase from Lockheed-Martin.³³ Israel initially intended to receive 19 Israeli Air Force specific modifications in their initial purchase. However, the rising costs of research and development made the additional integration costs unaffordable.³⁴ As a result, if Israel continues with the program as currently expected, they plan to receive the basic model delivered to all other nations with integration occurring at a later and, hopefully, more affordable date. As program issues and cost spikes continue for the F-35 program, it may only be a matter of time before one or more foreign partners determine, in a time of shrinking budgets, the F-35 will not fit into their air force.

On the domestic side, Congress finds itself torn over continued development and production of the F-35. Congress sees a divide over the aircraft from multiple perspectives. On one side they contend with a massive budget deficit that resulted in over \$450B in defense budget cuts through the next decade which may be managed by the single act of canceling the F35 program and producing more F16s and F15s. On the other side, they also deal with potential job loss and hurting the economy in a time of high unemployment. These contending issues result in Congress not taking decisive action for or against the F-35. However, the continued cost growth of the F-35 shows Washington that the Pentagon remains unable to complete a new program on time and on budget. As this fact happens again and again, it makes future new

programs within the Pentagon harder to get through Congress as they become more hesitant and less trusting of military leadership.

This paper spent a lot of time discussing the F-35 for numerous reasons. It discussed how and why it grew into the most expensive program in the history of the DoD. It also looked into the international and domestic concerns about the aircraft. Finally, it examined the precedent it follows and set of another military program failing come in on time and on budget. These issues play a role as the Air Force begins to study and develop a future, 6th generation fighter aircraft.

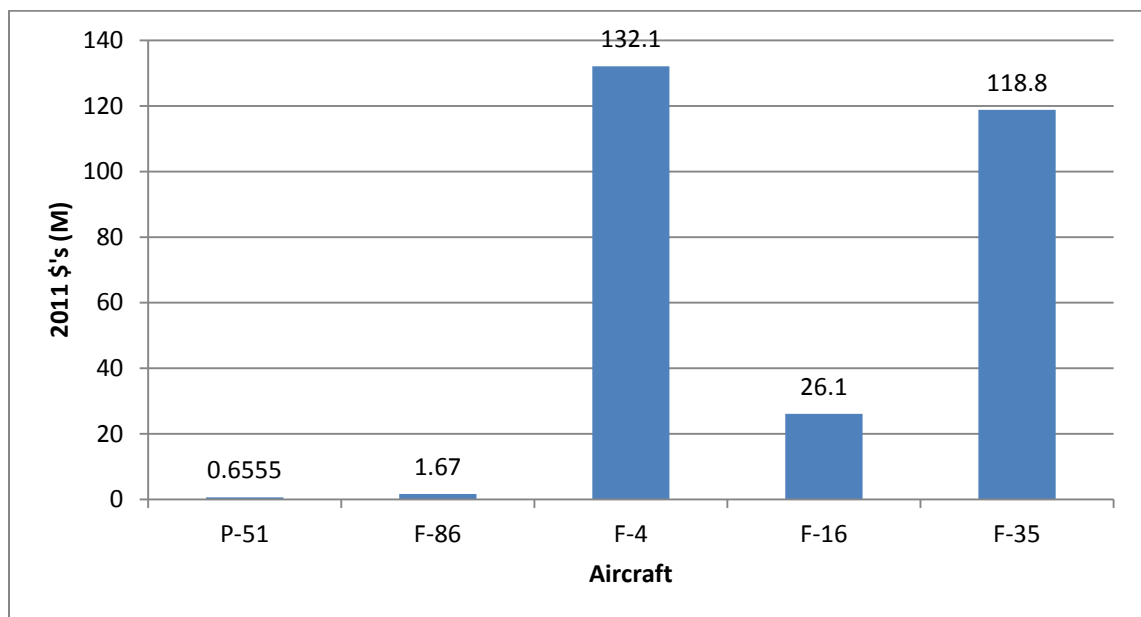


Fig 2. Cost per Aircraft in 2011 Dollars
Note: F-35 cost based on \$95M estimate in 2002 dollars

The 6th Generation Fighter

Why must the military begin studying a 6th generation fighter now? The timing arises from several perspectives. First, development and production of new aircraft in the past took approximately ten years. However, the F-35 timeline continues to push well beyond this frame. Second, potential adversaries continue to demonstrate technological advances making the current

fleet of aircraft nearly obsolete. Finally, the Air Force contains numerous weapons systems reaching the end of their safe service life. If these aircraft aren't replaced then the cost of maintaining legacy airframes increases dramatically and combat capability decreases.

On 3 November 2010, Air Force Materiel Command began market research concerning concepts and technologies for the Next Generation Tactical Aircraft (Next Gen TACAIR), essentially a 6th generation fighter aircraft. The Air Force requests industry provides an examination of:

...applicable materiel concepts and related technology for a Next Gen TACAIR capability with an IOC of approximately 2030. The envisioned system may possess enhanced capabilities in areas such as reach, persistence, survivability, net-centricity, situational awareness, human-system integration, and weapons effects. The primary mission in the future Next Gen TACAIR definition is Offensive and Defensive Counterair to include subset missions including Integrated Air and Missile Defense (IAMD), Close Air Support (CAS) and Air Interdiction (AI). It may also fulfill airborne electronic attack and intelligence-surveillance-reconnaissance capabilities. This is not an all-inclusive list and the Next Gen TACAIR definition will mature and sharpen as the market research and Capabilities Based Assessment (CBA) unfold.³⁵

The materiel and technologies search continues by outlining a number of key interest technologies in the following areas:

- a) Air Vehicle
- b) Vehicle/Sensor Protection
- c) Propulsion
- d) Warning and Situational Awareness
- e) Sensors
- f) Data Fusion
- g) Offensive/Defensive Systems
- h) Automatic Target Recognition (Ground and Air)
- i) Communications, Networks, and Data Links
- j) Kinetic Weapons
- k) Non-kinetic Weapons
- l) Electronic Warfare and Information Operations
- m) Secondary Power Generation, Storage and Management
- n) Thermal Management and Heat Rejection
- o) Human System Integration (HSI)
- p) Remotely Piloted Aircraft (RPA) and Optionally Manned Systems³⁶

In order to better understand the requirement for a follow-on aircraft to the F-35 by the Air Force's current plan of 2030, this paper is going to look at four aspects of the of aircraft: mission, capabilities, potential enemy/threat, and manned vs. unmanned configuration.

Mission

Air Combat Command (ACC) currently leads the Air Force's efforts in determining the requirements and missions for the 6th generation fighter. Sterling Anderson, Deputy Chief Air Superiority, ACC, engaged industry and the Aeronautic Systems Center (ASC) to perform a capabilities analysis to understand the technology and threat from 2030 to 2050.³⁷ ACC currently intends to maintain 1,200 combat configured aircraft during this time period. However, the primary concern for the Air Force stems from the fact that, by 2030, all combat fighter aircraft (F-15C/D/E, F-16C, F-22) except the F-35, are scheduled to be beyond their life expectancy and retired from the fleet.³⁸ This issue resulted in the Air Force anticipating the 6th generation fighter replacing both the airframes and the capabilities they provide in a single platform.

As spelled out in the Air Force's materiel and technology concepts search, the military expects the next generation fighter to complete multiple missions. These include: Integrated Air and Missile Defense (IAMD), Close Air Support (CAS) and Air Interdiction (AI) along with potential electronic attack and intelligence-surveillance-reconnaissance (ISR) capabilities. In essence, the next generation fighter continues the role of the current F-16 and upcoming F-35 by taking over the jack of all trades capacity. According to Mr. Anderson, ACC currently views the primary role of the next aircraft as air superiority and Suppression of Enemy Air Defenses (SEAD). However, they intend for the aircraft to contain an embedded ISR and Battle Management Command and Control (BMC2) role.³⁹

This multi-role mindset provides insight into several developmental issues and concerns prior to design even beginning. First, the Air Force must determine if the next generation aircraft intends to be a step forward or a leap forward in capability.⁴⁰ As an example of a step vs. a leap, the F-86 provided a leap forward from the P-51 due to the new jet engine. However, the F-16 showed just a step forward compared to the F-4 due to new technology but not a drastic increase in technological performance. This drives potential timelines required to develop the determined capabilities and also sets the stage for the associated costs of advancing and integrating the desired systems. Second, the technology required to perform all of these missions beginning in approximately 2030 probably remains in the developmental stage making cost determination limited. Third, the yet to be determined size of the aircraft may provide a limitation on the equipment available to perform missions. This may result in airframe limitations to performance, speed, efficiency, or capability in executing each mission. Having performed maintenance on the F-16 and worked in modernizing the aircraft, the author has seen how space limitations and original design complications made upgrading systems more difficult and expensive. As the Air Force looked to upgrade the radar system on the F-16, the space limitations impacted the ability of the aircraft to properly cool the new equipment which potentially results in higher fail rates and degraded capabilities. Fourth, the wide range of proposed capabilities sets an expectation that the Air Force intends to purchase a large number of these aircraft as replacements for the F-22 and potentially the F-35. This means the Air Force may possibly put all of its eggs into a single basket making project failure harder to swallow. This could result in the same problem seen in the F-35, despite growing costs and slipping timelines, the Services cannot afford to cancel it and start from scratch. Finally, it shows the Air Force understands that it cannot afford a specialized aircraft. The F-15C was the first fighter

aircraft in the Air Force inventory with a single mission, air superiority. The Air Force then followed this with the F-22 that also focused on the sole mission of air superiority. However, shrinking budgets, increased costs and a smaller force make this single mission aircraft appear impractical in the future.

While the missions the next generation aircraft performs are vital in the overall research, development and production, the Air Force is currently working to determine the specific capabilities required. They must make it their goal to accurately predict the technologies available, the threats present, and the minimum/maximum combat capability required to perform the myriad of missions they anticipate the next generation fighter aircraft performing.

Capabilities

The Air Force must determine if the next generation fighter provides a small step forward in capabilities or a large leap. These competencies extend beyond just type of mission assigned. They include airframe performance, engine performance, types of weapons, sensor proficiencies, and the integration of these systems into a single, unified platform. Some of the requirements are very obvious; the aircraft will be stealth, it will be able to fly beyond mach 1, it will carry air-to-air and air-to-ground weapons. However, the Air Force must clearly determine the range of these capabilities. How does the next generation stealth capability compare to the F-35? Will the aircraft fly at hypersonic speeds? Will the weapons continue in today's conventional format or will the new aircraft possess some type of energy weapon? More importantly, the Air Force, by necessity, must predict what is required. Furthermore, the Service has the obligation to complete the assessment quickly while forecasting the threat and the technologies to make the aircraft both survivable and lethal in the 2030 - 2050 timeframe.

One example of how the Air Force may work to change its development process is through describing the effect required from the aircraft as opposed to the capability. During an interview with Mr. Richard Tobasco, Advanced Platforms (AF/A5RC), he explained how the Air Force is trying to make this shift. He said that, while the aircraft will contain some specific requirements like being able to survive in an advanced integrated air defense system (IADS) environment and certain range and loiter times, they prefer going to the industry leaders and stating what effect they need the aircraft to provide.⁴¹ This change from capabilities to effects allows industry to determine the best/most effective/cheapest method available and allows each developer to demonstrate potentially unique solutions to the same problem. The Air Force's ability to change its thinking may play a large role in the program start and effectiveness.

The effects determination on a potential next generation fighter may prove even more vital in this case than previous generations. This is based on the tight timeline any new aircraft finds itself on in order to meet the Air Force's fielding goal of 2030. Aircraft development has become a longer, more complicated process. For instance, the F-4 program started in 1954 and the Air Force received its first one in 1965. Likewise, the F-16 program began in 1972 and the first aircraft entered service in 1979. Unfortunately, this rapid development and fielding ended with the F-35. As previously discussed, the program began 1997 with intended fielding in 2011. However, this timeline continues to slip and can be attributed to multiple factors. The one development item that appears to impact the F-35 the most comes in the software issues. As Michael Sullivan, the GAO's Director Acquisition and Sourcing Management, stated in his report to Congress, "Officials underestimated the time and effort needed to develop and integrate the software, substantially contributing to the program's overall cost and schedule problems and testing delays..."⁴² Needless to say, software development in a 6th generation aircraft will prove

vital to the overall performance and capabilities it provides the warfighter. While the DoD and industry hope to learn from the experience of the F-35, it does not mean that a new aircraft can be developed and fielded in the next 18 years as the Air Force plans. However, as the Air Force begins the determination of requirements and capabilities, it must keep in mind the effect required and, more importantly, the potential enemy it may face.

Potential Enemy/Threat

As research and development begins on the next generation fighter, the Air Force must focus on the threats it anticipates having to attack and survive in future conflicts. As we all know, the number and types of threats against our national security changed immensely following the Cold War. Today, the world holds a wide variety of dangers to our security. These include: near peer competitors (China and Russia), state actors (Iran), non-state actors (Taliban), and a host of terrorist, criminal and other entities that may emerge over the next 20 – 40 years.

However, the Air Force continues working to look beyond a specific enemy and focusing on the threat and spectrum of conflict in which the aircraft must operate. During discussions with Major Daniel Hingley, AF/A5RC Chief of F-22/F-X Fighter Requirements, he made it clear that any potential next generation fighter aircraft must be capable of surviving and operating across the full spectrum of warfare. Obviously this range starts at low intensity conflicts up to full-scale war with a near peer competitor. It is notable in this regard that the F22 has not seen any combat in any of the recent conflicts in which the US has played a part. This fact means the aircraft must be designed and equipped to operate against the highest threat it could potentially encounter. These high end capabilities mean that an aircraft must be able to guarantee mission success, survivability and battle space requirements which all play major roles in the

development time and cost of any future aircraft systems.⁴³ As a result of the high end threat requirement, the Air Force must examine near peer competitors and their capabilities along with the IADS systems potentially available in the 2030 – 2050 timeframe.

The current near peer competitors are Russia and China with India right around the corner. All of these countries continue modernizing their air forces. Additionally, Russia intends to field their 5th generation fighter in 2016 with the Chinese following shortly after in 2020.⁴⁴ As our military learns more about these two aircraft, the ability to counter them will become clearer in order to ensure the next generation can maintain air superiority. However, while these nations design and build stealth aircraft, the cheaper alternative remains available to most nations, a modern IADS leading to a high threat, anti-access aerial denial environment.

Historically, integrated air defense systems consisted of an array weapons to operate in coordination to provide maximum coverage at long, medium and close range. Typically, the long and medium range weapons involved surface-to-air missiles (SAMs) while the close range weapons included radar or optically guided cannons. One of the most comprehensive and deadly air defenses of the 20th Century resided in North Vietnam. From 1967 – 1974, the US Air Force lost 1,553 aircraft to a combination of ground fire and SAMs.⁴⁵ This means that nearly 69% of all Air Force downed aircraft came as a result of the North Vietnamese air defenses. This success led to a proliferation of the technology to many potential enemies of the United States, to include Iraq. However, the Air Force quickly proved how ineffective these systems had become during the air campaign to start OPERATION DESERT STORM. The jamming and precision strike capability brought to bear by the US and its allies quickly destroyed or silenced the anti-air weapons and resulted in the coalition achieving air dominance for the duration of the conflict. Furthermore, the allied offensive demonstrated the capability of stealth technology, in the form

of the F-117, to operate without fear from the legacy technology. The seeming invincibility of stealth helped the Air Force garner support for the B-2, the F-22, and now the F-35 along with the smart, precision guided munitions required to complete the kill chain. However, the enemies' attempts to counter both stealth and precision continue to evolve.

Russia, China, and other nations began focusing their defense efforts to counter the stealth threat shortly after OPERATION DESERT STORM. Additionally, they've worked to counter the threat through multiple methods. First, as the technology grows smaller and more mobile, the former fixed SAM sites become less and less prevalent. The new SAM systems focus on the ability to move, stop, set-up, shoot, and move again in approximately 6 minutes.⁴⁶ This mobility prevents friendly intelligence from accurately plotting and targeting enemy air defenses. Second, the utilization of jammers to counter GPS guided munitions continue to grow in effectiveness while also becoming cheaper and easier to procure. Jamming of this type represents a threat to not just precision weapons but, potentially, to aircraft guidance. However, in the short term, it means that fewer and fewer current generation munitions will strike their target as anticipated. Third, and possibly most important, these nations placed great emphasis on combatting stealth technology through the utilization of new technology, radars, and bandwidth.⁴⁷ The question is, what does this mean for a potential 6th generation fighter?

The increasing lethality of next generation IADS impacts the US military in many ways. First, the survivability of legacy weapon systems (F-15, F-16, F-18) decreases immensely and stealth technology becomes a requirement. Second, a new generation of GPS and GPS guided munitions must be developed and incorporated into any potential future aircraft to include the F-35. Third, speed and agility become key components of future designs in order to provide increased survivability of the aircraft. Finally, advanced anti-radiation munitions, jammers, and

other countermeasures become higher priorities for development and inclusion in any future weapon systems.

The potential threat presented by near peer competitors on the highest spectrum of warfare show a requirement for a next generation fighter aircraft. Russian and Chinese stealth aircraft provide tangible threats to current American technological superiority. Furthermore, advancements in IADS lead to legacy aircraft being unable to survive future anti-access aerial denial environments. It also means the military must answer the most important question concerning any potential future fighter; will it be manned or unmanned?

Manned vs. Unmanned

For the purposes of this paper, I will only address a single aircraft solution. I will not discuss a “system of systems” or a manned plane accompanied by a fleet of unmanned weapons platforms. Furthermore, my definition of unmanned for this paper is comparable to the current fleet of Predators and Global Hawks where a ground station maintains control of the aircraft throughout the flight. Unmanned does not equate to a self-guided drone or an aircraft controlled through artificial intelligence computer located on-board.

The Air Force currently possesses a fleet of both manned and unmanned aircraft. However, the manned fleet continues to shrink as aircraft reach their retirement age and budget cuts impact the force size. At the same time, unmanned aircraft fleets continue to grow as the need for their specialty, ISR, remains high with on-going operations in Afghanistan and around the globe. As recently as 2005, manned aircraft made up 95% of the military fleet. Today, the manned fleet only provides 69% of the aircraft.⁴⁸ However, the Air Force’s current and upcoming aircraft acquisition programs (F-35, KC-46 and the new long ranger bomber) are all

designed or planned as manned aircraft. Each configuration provides its own set of pros and cons for a potential platform.

Manned aircraft provide the backbone of the current Air Force fleet across the spectrum of platforms. As a result, the military and industry lean in this direction for future development ideas based on experience and current technology. With this experience come specific pros to a manned fighter. First, as people, we still trust the pilot to make the proper decision prior to any action, from dropping a bomb to firing a missile. Second, we expect a human pilot to absorb information, integrate these inputs, and reach a decision faster than a ground station pilot because he is relying on his senses and what he can see around him as opposed to the unmanned pilot who can only see what the camera shows him. Third, current manned aircraft remain much larger in size allowing for greater payloads, ranges, and roles. While these are only three pros, they can be contrasted with the pros of remotely piloted aircraft (RPA).

RPAs also demonstrate several advantages over their conventional counterpart. First, they are currently much cheaper. This may change as their capabilities and roles increase but certain aspects, not requiring life support systems or a cockpit, help ensure that costs remain below manned aircraft. Second, their performance is not limited by its weakest link, the human pilot. Third, by not being manned, the aircraft can be sent into a more hostile environment without endangering the life of the pilot. Finally, an unmanned aircraft can be built with greater stealth characteristics based on the fact that one of the least stealthy portions of current manned airframes is the cockpit. However, both fleets also provide a number of negative aspects.

A new generation of manned aircraft incurs several negative issues. As previously discussed, these aircraft tend to be more expensive, limited by the pilot, and leadership becomes more risk adverse. In addition to these issues, manned aircraft carry large bills when considering

the cost to train a pilot. Based on 2009 figures, training a pilot to fly fighter aircraft cost the Air Force \$2.6M per person.⁴⁹ Additionally, by removing the person from the cockpit, the Air Force is better able to remove the emotion from the cockpit and the decision making process. However, while the cons of manned aircraft focus on the pilot, the cons of unmanned aircraft focus on the limitations in current technology and the increases in the enemies' capability to counter these aircraft.

Given the recent RPA incident with Iran, the largest concern with unmanned aircraft focuses on the ability to maintain communication link. As jamming becomes cheaper and more available, the ability of future threats to jam this link or even possibly override and take over the aircraft becomes a larger issue. Additionally, RPAs continue to show an increased propensity to crash during takeoff, landing, or based on loss of communication, even in low threat environments. Finally, while technology advances make information synthesis easier for RPA pilots, as Lt Gen Deptula states, "we have a long way to go to achieve the degree of 360-degree awareness, rapid assimilation of information, and translation of that information into action that the human brain, linked with its on-site sensors, can accomplish."⁵⁰ These limitations, linked with the potential lack of reliable, constant communications, demonstrate the greatest cons to a potential 6th generation, unmanned aircraft.

While the potential missions, proposed capabilities, future threats, and configuration options provide detailed background and insight into what a future fighter aircraft may look like, it fails to answer the question; will the Air Force field a 6th generation fighter by its proposed 2030 timeline?

What Does 2030 See?

The United States Air Force will not have a new, 6th generation fighter aircraft in 2030. Given current budgets and shifting of budget priorities away from the military for the foreseeable future, the Air Force cannot afford this aircraft in the proposed timeline. Furthermore, its potential position on the Air Force acquisition priority list would fall behind the F-35, KC-46, and the long range bomber. Other obstacles also clog the path to a new fighter. The trials and tribulations of the F-35 make the start of a new fighter politically untenable at this time. The government and the American people must see results from the F-35 program before they can stomach starting a new one. Furthermore, the technology to make a true next generation fighter will not be mature enough to enter the fleet by 2030. Stealth technology will continue to improve but the next leap in generations will come in the propulsion and weapon systems. Additionally, the next generation fighter will be unmanned but again, the technology will not allow this to be possible by the 2030 timeframe.

However, there are two caveats: the Air Force will have its 6th generation aircraft someday and it will have a new fighter aircraft by 2030. This new fighter will be a generation 5+ type of aircraft. Similar to how the F-16 did not provide a generational leap forward as it followed the F-4 in the 1970s, so the 2030 fighter aircraft will provide a step forward and an interim capability as technology matures. Furthermore, as previously discussed, if the Air Force does not develop an interim solution then 2030 sees the fleet with a single fighter aircraft, the F-35. Throughout its history, the Air Force relied on multiple airframes to maintain combat capability and it cannot afford to limit itself to a single option.

In order to provide this 5+ generation aircraft, the DoD will be forced to prioritize over the coming decades. First, how many F-35s can it afford at the current price. That number may drop drastically if program slips and cost increases continue at the current rate. Additionally, the

Air Force will have to determine the capabilities and associated price tag with the next long range bomber. Finally, the number of KC-46 aircraft purchased may decrease in order to maintain a combat capable fighter force from 2030 to 2050. All of these factors lead to many difficult decisions for senior Air Force and DoD leadership in the very near future.

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