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Scorecard
A Case study of the Joint Strike Fighter Program

by

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Disclaimer

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Abstract

This is a case study of the JSF program's ability to deliver on its original promise of an affordable, next generation strike-fighter for three separate U.S. services as well as a number of foreign militaries. Although fiscal realities may have driven the services to jump on board the JSF bandwagon, the program has not been run in a manner yielding the highest cost benefit ratio possible. This is primarily due to the services’ short memory when authoring key performance parameters coupled with the seemingly proven fact that joint acquisition simply is not an effective way to provide TACAIR assets to our services.

The JSF has been a hot debate amongst policy makers, service leaders, and operators. Service leaders are in the hot seat as they must try and walk the fine line of what they need and what they can sell to Congress. Although some may argue that we made small concessions in the name of commonality, others claim otherwise. Some decisions will affect operators for decades to come. The decision to build the JSF around a single engine will never cease to haunt carrier aviators and those on transoceanic ferrying missions. The decision not to include an internal cannon on the Navy and STOVL variants now appears questionable in light of recent theater use of the weapon for close air support. Finally many would argue that buying an aircraft for the future with less “raw” performance than the fighters in our current inventory will catch up with us in the end. Avionics and stealth technology are inherently defeatable; in the end it will always be important to outperform your opponent.

This study will attempt to produce a scorecard for the JSF program. It will admittedly merely scratch the surface by analyzing the very basic performance capabilities of the airframe. Three questions were asked in order to determine the overall success of the program: What did the services demand? Did the services demand what they needed? Did the JSF program deliver

on its promise? The answers to these three questions certainly shed light on the success of the JSF program.

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Chapter 1
Introduction

The JSF program was formed by combining the Joint Advanced Strike Technology (JAST) and the Advanced Short Take-off and Landing (ASTOVL) programs in 1995. This is not the first time the United States has gone down the road of joint acquisition. In the 1960's Defense Secretary Robert McNamara established the Tactical Fighter Experiment (TFX) program as an answer to the Navy's desire for a new fleet air defense fighter and the Air Force's need for a long range nuclear and conventional delivery vehicle. The end result of the program was the Navy cancelling their involvement and leaving the Air Force with a highly compromised airframe barely capable of delivering on the required mission; the resultant F-111 was delivered at an estimated five times the original sticker price.[1]

Fast forward to the 1993 *Bottom Up Review*, the services combined have five different platforms on the drawing board: the Multi-role Fighter, the A/F-X, the F/A-18 E/F, the F-22, and the Short Take-off Vertical Landing Strike Fighter. It was the infeasibility of funding all five programs that forced a compromise in the form of the JSF program. Although it may seem ridiculous to fund five different programs, each served a specific role and would be operated by separate services with the exception of the Navy and Air Force operating two each. Is it realistic to assume that technology has developed in a manner over the last 40 years to allow a single airframe to be designed to operate from a runway, an aircraft carrier, and an unimproved strip without serious concessions in performance?

The JSF is the source of a lively debate amongst policy makers, service leaders, and operators. Service leaders are in the hot seat as they must try and walk the fine line of what they need and what they can sell to Congress. Although some may argue that small concessions were made in the name of commonality, others claim otherwise. Many believe that joint acquisition by definition is destined for failure. Most opponents point to the failure of the TFX program as proof that a joint program could never succeed in the future.

Much research has been conducted comparing the JSF program to the TFX program of the 1960's. It appears to be a valid comparison as the very mention of one of these programs creates an almost passionate response from the separate services involved. The two programs, however, were not conducted in the same manner at all. The TFX program was not jointly conceived. It was the result of the Navy being forced to join an existing program to fill its needs after the Secretary of Defense cancelled its fleet defense aircraft program.[2] The TFX program was also not jointly managed; the USAF had complete control with the Navy only providing liaisons within the TFX office.[3] Finally, the TFX performance requirements were developed in a vacuum completely independent of industry participation.[4] The JSF program was developed to avoid the pitfalls of the TFX program. It was joint from its inception to include rotating service management as well as ample industry participation.

Considering the two programs were conceived and managed completely differently, the JSF program has the chance to be the first successful example of a joint acquisition program. It will obviously take years to truly see its success, but a cursory look at its present status may shed some light on whether there is even a chance that it will be viewed as a positive example of joint acquisition. Although the services involved appear to be following the party line by publicly supporting the JSF, there are still many opponents to the program who say it will not produce a reasonable solution to its proposed users.

The JSF program promises to "affordably develop the next generation strike fighter weapons system to meet an advanced threat (2010 and beyond), while improving lethality, survivability, and supportability."[5] Whether or not this can be accomplished across service lines is highly questionable. This study will attempt to address the success of the JSF program based on three questions: What did the services demand? Did the services demand what they needed? Did the JSF program deliver on its promise?

For the purposes of this research, political issues such as the wisdom behind exporting low-observable and stealth technology will be ignored. It will focus on the three U.S. services as the consumer and will not address the needs of proposed foreign sales customers. In addition, this research was conducted at the unclassified level and will make statements and assumptions that I will concede could very well be defended or countered at the classified level. The focus will instead be on whether or not the joint JSF project will deliver any of the services the aircraft they truly need.

Chapter 2
What Did the Services Demand?

Disregarding the fiscal restraints placed on the services and focusing singularly on the Performance Parameters laid out in the Operational Requirements Document (ORD), some light can be shed on whether the individual services asked for what they actually needed. This research will not delve into the minutia by listing every small detail, but will focus on the high visibility items that contribute to basic combat performance.

Due to the classification level of this research and discussion, certain concessions must be made. The JSF anchors a large portion of its capability on the idea of low observable (LO) and stealth technology. Because of the sensitivity of this technology, details are only available at the classified level and will not be discussed here. For the purposes of this research, it will be assumed that the LO and stealth technology incorporated into the JSF is sound and will meet any requirements of the services. This is certainly a large leap of faith, but this research focuses primarily on basic combat performance and the ability of the JSF program to make good on its promise of an affordable, strike capable, fifth generation fighter for the future of three separate services.

Performance parameters are separated into three categories: joint, common, and service specific. Joint parameters are used when the attribute and criteria are the same, common parameters have the same attribute but different criteria, and service specific are self-explanatory.[6] Some capabilities list a general joint parameter and then break it down further into common parameters; these will be discussed in the *Common Performance Parameters* section. Parameters are further identified by the services as either "key", "threshold", or "objective." *Key performance parameters* are considered so significant that a failure to meet them could be cause for reassessment or termination of the program. A parameters *threshold* delineates the minimum acceptable performance of said parameter whereas *objective* reflects the desired capability beyond the minimums.[7] For the purposes of this discussion it can be assumed that a required parameter listed is the *threshold* unless stated otherwise.

Joint Performance Parameters

The majority of the basic handling characteristics, weapons carriage and release, interoperability, and maintenance parameters are the same for each service. This is a testament to the *commonality* of the JSF, but questions could be raised as to whether the correct parameters were agreed upon by the services.

The basis for all the requested capabilities is that the JSF "must affordably optimize lethality, survivability, and supportability in a 'best value' solution."[8] Lethality is addressed by the requirement for reduced signature and full integration into the C4ISR structure. Survivability calls for increased countermeasures and standoff weapons coupled with low observable and stealth technology. Supportability improvements will come in the form of a reduced logistics footprint, high commonality, and lower life cycle costs. Whether these high expectations are met will not be known until long after the JSF is in service.

The cornerstone of the combat effectiveness of the JSF lies in its proposed stealth technology and integration into the C4ISR architecture. The success in developing stealth technology has been conceded, but a look into what the Operational Requirements Document plans for its interoperability is worthwhile. The JSF team considers interoperability a *key performance parameter*. The JSF will be required to have:

> … an interoperable C4I system that incorporates secure voice and data transmission capability, automatically fuse data into an easy, understandable format to the aircrew, and for seamless aircrew initiated input to combat systems and weapons. F-35 is to ensure line-of-sight (LOS) transmit/receive communication and data transmission systems have the

> linkages and associated bandwidth to pass and receive timely information, to include: broadcast (e.g., threat updates, weather), command and control, inter/intra flight datalink communications, FAC communications, and aircraft status reporting information. BLOS transmit and receive of voice and data is a key enabler of JSF Lethality and Survivability…F-35 must communicate in a hostile environment (e.g., jamming, intrusion, spoofing, and exploitation) through an information management architecture that is open and modular to facilitate future integration of new or updated C4I functionality requirements…F-35 must have sufficient on-board computing capability to perform fusion of data from on-board and off-board sensors. This on-board computing system should automatically provide an integrated picture of the battlespace with its associated situational awareness to the aircrew that provides the flexibility to adjust the mission plan, if required.[9]

The ORD further states that the JSF must meet 100% of critical, top-level Information Exchange Requirements (IER).[10] These are critical information sources and systems from external agents such as combatant commanders, agencies, and allied or coalition partners.

Commonality is considered the simplest and most concrete way to cut overall costs in the JSF program. The theory is that by creating an aircraft that provides many of the high-cost parts as common across all variants, the overall cost will be lower. Target areas include engines, avionics, and structural components of the airframe.[11] The requirement is for 70%-90% of components to be common across the three variants.[12]

Common Performance Parameters

There are several performance based parameters for which the services authored different *thresholds* and *objectives*. These differences were typically based on a service's unique mission requirements.

Combat radius is a *Key Performance Parameter* and is unique to each model of the JSF. Each service's threshold and objective combat radius parameters are listed below in Figure 1.[13] The Navy's significant difference is based on its unique mission operating procedures that require not only more fuel for longer mission distances, but a larger reserve upon return to the aircraft carrier. The USMC STOVL version's shorter range is based on its expeditionary mindset that assumes the mission will originate organically and therefore closer to the target area.

Figure 1

Combat Radius

Variant	Threshold	Objective
CTOL (USAF Profile)	590 nm	690 nm
CV (USN Profile)	600 nm	730[1] nm
STOVL (STOVL Profile)	450 nm	550[1] nm

1. May include external fuel tank capacity that minimizes impact to signature, drag, performance, and external payload.

Payload requirements were similar for all three variants but differed in their demand for an internal gun. All variants called for at least four external stations capable of carrying all threshold weapons. A minimum of two stations must be capable of carrying and be plumbed for fuel tanks. The internal payload is where the difference is noted. All three required the ability to carry two AMRAAM air-air-missiles and two air-to-ground weapons in the two-thousand pound class, but there was disagreement on the need for an internal gun. The CTOL variant demanded an internal gun, the STOVL called for a missionized gun, and the CV variant required that space be provided for either an internal or missionized gun.

The airspeed requirement also shares some similarities across all three variants. The JSF shares a requirement for its *operational limit speed* for each variant but differs slightly when it comes to requirements for operational speeds in level flight.[14] The limit speed with internal weapons is 700 knots calibrated air speed (KCAS) or 1.6 MACH, whichever is less, "in order to provide adequate dash capability for a bugout maneuver."[15] The level flight speed requirements for each variant are listed below in Figure 2.[16] The configuration for the speeds listed is internal weapons only and makes no concessions for external pylons or weapons. The only notable difference is that the USAF CTOL variant requires the ability to achieve 1.0 MACH at sea level using maximum power.

Figure 2

Speed

Altitude:	Threshold	Objective
Sea level – Mil Power Dash **CTOL/CV** **STOVL**	 630 KCAS 600 KCAS	 660 KCAS 630 KCAS
Sea level – Max Power Dash **CTOL only**	1.0 Mach	1.1 Mach
30,000 ft. – Mil Power	>0.96 Mach	1.0 Mach
> 30,000 ft. – Max power	1.5 Mach	1.6 Mach

Maneuverability is addressed in both general and specific terms. The requirement for all three variants is to provide a platform that will have a positive exchange ratio during air combat maneuvering (ACM) engagements against "high performance threats that employ helmet mounted cueing and high off-boresight weapons."[17] The JSF must further possess high angle of attack (AOA) capabilities "similar in nature to (or better than) the F-18C."[18] The fuel levels and payloads at which maneuverability is calculated differs for each variant but generally focuses on a post-weapons release payload and fuel state at 50% of the required combat radius. Figure 3 below lists the specific maneuverability requirements and shows the differences among the variants.[19] The most notable differences are related to the USAF requirements for the CTOL JSF. The USAF includes a *threshold* requirement for a 9.0 G capability at 60% fuel and no air-to-ground ordnance remaining. In addition to the high-end requirement, the USAF also provides for a more realistic scenario of high altitude, large payload performance. The CTOL must have the capability of performing a 30 degree bank turn while still maintaining a 1000 foot per minute climb at 30,000 feet with a combat loadout of two external fuel tanks, two external JDAM, two internal JDAM, two internal AIM-120 missiles, and a fully loaded gun.

Figure 3

Maneuverability

	Threshold	Objectives
Corner Speed CTOL/CV	F-16 like	F/A-18 like
Instantaneous G STOVL **(At 15K feet)**	+7.0 320 KCAS	+7.5 305 KCAS
Sustained G CTOL **CV** **STOVL** **(At 15K feet/.8 Mach)**	+5.3 +5.1 +5.0	+6.0 +6.0 +6.0
Sustained G CTOL[1] **Mil Power performance at 30K ft ≤0.9M**	Sustained 30 degree bank turn 1000 fpm climb (straight and level).	Sustained 45 degree bank turn 2500 fpm climb (straight and level).
Acceleration: CTOL **CV** **STOVL** **(At 30K feet/0.8 to 1.2 Mach)**	≤ 55 sec ≤ 65 sec ≤ 65 sec	≤ 40 sec ≤ 45 sec
Ps STOVL **(At 15K feet/0.8 Mach)**	550 feet/sec	
G at Maneuver Weight CTOL[2]	+9.0/-3.0 (Mach ≤ 1.05) +7.0/-2.0 (Mach > 1.2)	
CV	+7.5/-3.0 (Mach ≤ 1.05) +6.5/-2.0 (Mach > 1.2)	+8.0/-3.0
STOVL	+7.0/-3.0 (Mach ≤ 1.05) +6.0/-2.0 (Mach > 1.2)	+8.0/-3.0

1. Configuration: 2 x empty external 370 gallon tanks internal fuel for 540nm combat radius, 4 x JDAM Mk-84, 2 x AIM-120, gun with 150 rounds. Airspeed ≤0.9M.
2. With 60% of internal fuel load required for 540nm combat radius and JDAMs jettisoned/released.

Air Force Mission Needs and Specific Performance Parameters

The USAF needs a strike fighter to replace the venerable A-10 attack platform and the aging F-16 multirole fighter. This replacement would be the "second tier" fighter behind the F-22 and perform the CAS role left empty by the A-10. The Air Force intends on buying large numbers and will need the costs kept reasonable. The JSF will be used to "support the USAF core competencies of Air and Space Superiority, Global Attack, Precision Engagement, and Agile Combat Support."[20] It will complement the F-22 and bomber assets within the Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) architecture making interoperability essential to combat effectiveness. Interoperability is seen as crucial because future operations are expected to require seamless information flow from the tactical to strategic (to include the President and Secretary of Defense) levels and back.[21] Fulfilling these expectations under a program whose self-proclaimed cornerstone is "affordability" would be a tall order and require the USAF to pick and choose performance requirements carefully.[22]

Navy Mission Needs and Specific Performance Parameters

The Navy needs a fifth generation stealth fighter/attack platform to replace its aging legacy F/A-18 A-C models and to complement the F/A-18 E/F. It is essential that the JSF work seamlessly with organic Carrier Strike Group assets as well as other assets within the joint and combined force structure.[23] The Naval variant must have full interoperability within the C4ISR structure. In addition, CV variant must be capable of operating from both current CVN class carriers as well as future CVX models.

The capability to operate from a carrier is not as easy as it sounds. Additional weight comes in the form of stronger landing gear, fuselage center barrel strength, arresting hook structure, and additional electrical power requirements. The Navy has added approach speed as a service specific *key performance parameter.* The *threshold* for approach speed is 145 knots with 15 knots of wind over the deck.[24] This must be possible at Required Carrier Landing Weight (RCLW). The RCLW is the sum of the aircraft operating weight, the minimum required bringback, and enough fuel for two instrument approaches and a 100nm BINGO profile to arrive at a divert airfield with 1000 pounds of fuel.[25] The minimum required bringback is two 2000 pound air-to-ground weapons and two AIM-120s. The Navy further requires that the CV JSF be capable of carrier recovery with internal and external stores; the external stations must have 1000 pound capability on the outboard stations and maximum station carriage weight on the inboard.[26]

Marine Corps Needs and Specific Performance Parameters

The Marine Corps requires a Short Take-Off and Landing (STOVL) multi-role fighter to replace its aging AV-8B as well as its conventional F/A-18 A-C aircraft. The USMC variant must be able to operate from expeditionary airfields, Amphibious Assault Ships, and current and future Aircraft Carriers.[27] The JSF must be able to meet or exceed legacy aircraft capability while incorporating stealth technology. It must further be fully integrated into the joint C4ISR architecture.[28]

The Marine Corps has the added requirement of STOVL performance to address. The USMC has added STOVL performance as a service specific *key performance parameter*. The requirement is listed as follows:

> With two 1000# JDAMs and two internal AIM-120s, full expendables, execute a 550 foot (450 UK STOVL) STO from LHA, LHD, and aircraft carriers (sea level, tropical day, 10 kts operational WOD) and with a combat radius of 450 nm (STOVL profile). Also must perform STOVL vertical landing with two 1000# JDAMs and two internal AIM-120s, full expendables, and fuel to fly the STOVL Recovery profile.[29]

The Marine Corps has used the more limiting deck launch, rather than a simple expeditionary airfield, to frame its requirement.

Chapter 3
Did the Services Demand What They Needed?

The Operational Requirements Document lays out a seemingly robust list of requirements that covers everything from performance to maintenance and sortie generation rates. The high visibility items such as maintenance, sortie generation, logistics footprints, and C4ISR interoperability were addressed very responsibly. The JSF requirements called for significant improvements over legacy platforms in all of the above parameters. Although it is understandable that some concessions would have to be made in the name of affordability, the services may have come up short on basic design, performance, weapons, and dependence on low-observable/stealth technology.

Design

It would take a dedicated research to sufficiently analyze the JSF's make-up, but the JSF has one glaring design element that must be addressed; it was built around a single engine. The decision to build a single engine fighter was undoubtedly influenced by the JSF program's number one priority of cost. Although a single engine design certainly saves money in the areas of R&D and per unit costs, it could have a long term affect on the operating costs and safety of the JSF.

Naval Aviators, in particular, are sensitive to the idea of a single engine fighter. Scarred by years of operating A-4 Skyhawks and A-7 Corsairs, Naval aviators swore to never go down the single engine road again. The carrier operating environment is not forgiving to engine failures. With no ability to perform a "dead stick" or precautionary landing at sea, an irrecoverable engine failure would equal an ejection 100% of the time. When Rear Admiral Frank Dirren, head of the Naval Safety Center (in 2000) was asked what he would do in the case of an engine failure in the JSF, he replied "I'd give it back to the taxpayers, and go get me another one."[30]

Program officials and engineers point to the dramatic advancements made in the area of engine reliability and claim a comparison can not be made between jets from the 1960-1980 era and the JSF. Although there is some truth to that claim, operators know that engines will never have a 100% reliability, especially when combat damage is considered. Age of the aircraft will also play a role in the latter years of the JSF's lifespan. Inevitably the JSF will age to a point where it will be impossible to retain the original reliability of the system.

A look at our newest single engine fighter, the F-16, raises questions about engine reliability. In fiscal year 2007 the F-16 had a mishap rate of 3.18 per 100,000 flight hours with thirteen Class A mishaps.[31] Of the thirteen Class A mishaps six were due to engine failure.[32] Although this number is a ten year high, it demonstrates the danger of the single engine design. It must also be noted that the previous high mishap rate of 3.85 per 100,000 flight hours was reported in 2001 and was also attributed to a rash of engine failures.[33]

Loss of life is clearly the most important concern, but operational costs must also be considered. Each F-16 lost costs taxpayers $21 million whereas a single JSF could cost upwards of $121 million. When factored into the overall cost of the program, losses due to engine failure could have a significant impact. It is irresponsible to assume that technology has advanced enough in recent decades to eliminate the problems inherent with a single engine fighter.

Performance

The overall performance of the proposed JSF is highly inadequate to be considered a "next generation" fighter. The minimal, if any, increase in performance over the legacy platforms it intends to replace, proves that designers are completely dependant on stealth technology for its success. The services asked for adequate numbers in some areas, but fell drastically short in others.

Combat radius can be viewed as adequate. The numbers certainly provide a capability to outperform current fighters and do so using only internal fuel. That being said, it is naïve to assume that the JSF will operate in that configuration. With tankers as a limiting factor for any campaign, it is reasonable to assume that planners will quickly opt to add external tanks and stores to increase the range and weapons payload for the JSF. The effect of this will be twofold: the already low raw performance of the JSF will be degraded and, more importantly, the LO/stealth capability will be essentially eliminated.

The payload requirements are above average for the CTOL and CV variants. With an internal loadout the JSF can rival the combat radius and weapons loadout of an F/A-18 E/F or F-16. With external stations added, it can carry significantly more than the legacy platforms. The internal bay (on the CTOL and CV variants) is also well designed as it requires the ability to be able to carry two 2000 or 1000 pound weapons, four 500 pound weapons, or eight small diameter bombs. The USMC variant initially held the same requirements but was forced to reduce the internal carriage threshold to two 1000 pound weapons. This will severely limit the STOVL variant's combat effectiveness, especially in the CAS arena. This could prove to be a huge error considering CAS is the USMC's number one priority for TACAIR.

The airspeed requirements are highly inadequate. They barely provide the performance of an F/A-18 and fall well short of the F-16. They are, of course, vast improvements over the AV-8B and A-10, but that is hardly an argument for success when referring to a "next generation" fighter. The CTOL model calls for a threshold of 1.0 Mach at sea level. This requirement is for internal stores only and falls short of the capability of an F/A-18 with external stores.

Referencing the above discussion of the inevitable use of external stores, these requirements should have addressed an external configuration at the very least.

Maneuverability requirements also fall short. The instantaneous and sustained G requirements are adequate, although not impressive. The AOA threshold, however, is short-sighted. A threshold requirement for a fighter that possesses AOA capabilities "similar to" a legacy fighter platform is irresponsible at best. An aircraft that expected to have a service life well past 2060 needs to have superior raw performance in addition to advanced avionics. Software and avionics can always be upgraded, significant performance modifications can never be made.

By stating that the JSF would be a "next generation" fighter, it is assumed that performance will fall into the fifth generation category. While there can be some debate over the exact definition of a fifth generation fighter, the following is generally agreed upon: "fifth generation fighters combine new developments such as thrust vectoring, composite materials, supercruise, stealth technology, advanced radar and sensors, and integrated avionics to greatly improve pilot situational awareness."[34] Clearly the JSF can only claim two of these characteristics: stealth and interoperability through avionics. Other platforms such as the F/A-18 E/F that possess two "fifth generation" capabilities but lack stealth have been coined "4.5 generation" fighters. Without the unproven effectiveness of stealth, the JSF becomes a slower version of the legacy fighters it is attempting to replace.

CAS Capability and Weapons

The services each asked for a variety of air-to-air and air-to-ground weapons that would supposedly fill their combat needs for the future. At first glance the list appears adequate. It includes all the high visibility precision weapons as well as their conventional counterparts:

JDAM/LGBs and the conventional MK-80 series bombs needed to build them, JSOW, Small Diameter Bomb, Cluster Munitions, etc. In essence, the services put together a list fit for the first night of the war and ignored one of airpower's greatest contributions: Close Air Support (CAS).

CAS requires special training first and foremost, but also has specific weapons needs. The ideal CAS weapons are versatile, quick to employ, and usually must have a small but precise effect to avoid collateral damage. Although JDAM and MK-80 series weapons have certainly played a role in past CAS missions, they are hardly the weapon of choice. The main targets in CAS include vehicles, troops in the open, and occasionally buildings or other hardened targets. With the exception of the latter, the JSF does not have the weapons to be truly effective.

Moving targets will provide an issue for the JSF. Although laser guided bombs have been employed against moving targets in the past, their success rate is generally low. The greatest success against moving targets comes when using a Maverick air-to-ground missile (AGM) or the gun. The JSF will not be Maverick capable and currently only the USAF variant will have an internal gun.

Troops in the open are the most common target in CAS. Although one could argue that the JSF will be capable of employing cluster munitions, these are only useful when adequate separation is available. Enemy troops are typically in contact with friendly forces during CAS missions and require a truly discriminate weapon such as the gun.

The JSF is being pitched as a replacement for the F/A-18, F-16, AV-8B, and A-10. All are adept at CAS, but the A-10 rises above the others and provides a unique form of CAS that the others cannot. According to some, when the A-10 is retired, "its absence will put troops on the battlefield in grave danger."[35] It is the only U.S. aircraft that possesses the survivability, loiter time, and weapons to truly support ground troops. The A-10 was built for the CAS role; it was designed with engines set high and apart, a massive cannon, a titanium cockpit, triple redundant flight controls, and self-sealing fuel tanks.[36] The smaller agile fighters (including the JSF) could never be operated in the same manner as an A-10. That is not to say they don't contribute, but when a ground unit requires support in poor weather, only the A-10 will be allowed low enough to provide effects. The JSF will carry too high a price tag and be too vulnerable to operate in the low altitude environment. It will certainly see similar, or more restrictive, altitude restraints to those placed upon strike-fighters in the Bosnia, OEF, and OIF campaigns.

The JSF team did not request the correct weapons to adequately perform a CAS role. First and foremost, they needed to require a gun on all three variants. The gun provides options when all other weapons are expended or a small precise effect is required.[37] A capacity of greater than 180 rounds should have been requested; legacy fighters such as the F/A-18 and F-16 each carry over 500 rounds. Secondly, weapons such as rockets or the Maverick should have been included. Their capabilities have been proven time and time again against moving targets and can also be used in the place of an LGB or JDAM against larger targets such as buildings.

The JSF will be unable to adequately fill the CAS role of legacy strike-fighters, let alone that of the A-10. It does not bring the survivability, design, or weapons capability required to truly operate in support of ground troops in contact with the enemy. The JSF will leave a dangerous gap in CAS capability that will affect future conflicts for decades to come.

Low Observable/Stealth Dependence

The JSF has gambled much when it comes to survivability. It has put all its eggs in the proverbial stealth basket. Although this research has conceded that the JSF program will deliver on its promise of stealth technology, it is unknown whether this technology alone will be relevant in the future of combat operations. Because of the enormous investment made, the JSF needs to be the fifth generation answer for multiple services for decades to come. It may be naïve to assume that stealth technology alone will protect the JSF throughout its service life.

Many countries are currently developing technology to combat LO/stealth platforms. The USAF itself recognizes this and is currently working on the development of new versions of high-speed anti-radiation missiles for use in the F-22 and JSF. This could be a reaction to Russia's current programs aimed at developing upgrades to the SA-21's S-400 system.[38] The USAF is further worried that as technology advances and network cabling becomes cheaper, enemy defenses will be able to link various radar types to increase their chances of detecting and engaging LO/stealth aircraft.[39]

The UK has been researching anti-stealth technology since 2001 and has even researched the ability to use cell phone tower transmissions as a detection method.[40] Roke Manor Research Institute claims that it has "rendered stealth aircraft useless" through the use of passive bistatic radar.[41] Bistatic radar picks up the signals that are scattered by a stealth aircraft's design because the transmitter and receivers are not co-located.[42] The engineers claim that by listening for echoes from cell phone signals that bounce off stealth aircraft they can detect the aircraft and when coupled with GPS technology, determine its exact location.[43] Although it is generally agreed upon that a cell phone tower's signal is too weak to pose a valid threat to current stealth platforms, it is clear that a step in the right direction is already years into development.

A National Defense University Institute study claims that "the ability for stealth designers to hide the small, tell-tale emissions from large, expensive platforms…will be overtaken by the ability to collect and analyze data."[44] The theory is that sensor technology will become so small and inexpensive that it will become possible to deploy millions of sensors across the battlefield making it impossible to "clean up all the bits of information" as fast as they can be collected.[45]

A small capability against LO may already be airborne in various platforms. In a 2003 article, David Fulghum claims that some current platforms such as the EA-18G Growler possess a capability against LO platforms such as cruise missiles and even stealth aircraft.[46] Considering that there have already been significant advances in anti-stealth technology, it seems somewhat irresponsible to design an aircraft so dependant on its dominance. The F-22 is not considered the world's most dominant fighter because of LO/stealth capability, but rather its overall performance. The services fell short by not demanding protection through additional means for the JSF.

Chapter 4

Did the JSF Program Deliver On Its Promise?

The JSF program promised to "*affordably* develop the *next generation* strike fighter weapons system to meet an advanced threat (2010 and beyond), while improving *lethality*, *survivability*, and *supportability*."[47] The affordability was addressed by combining multiple programs into one that would use commonality to combat costs. Lethality and survivability would be attained via advanced technology, avionics, and countermeasures. Supportability would provide a reduced footprint along with lower maintenance costs via commonality and an advanced prognostic monitoring system. Is the JSF program delivering an aircraft with these qualities to the services?

Affordability

The cornerstone of the program is cost. The program was sold using affordability as its battle cry. Commonality was seen as the easiest way to save money. According to Former Secretary of Defense William Cohen, the JSF's joint approach "avoids the three parallel development programs for service-unique aircraft that would have otherwise been necessary, saving at least $15 billion." It can hardly be argued that the services were forced to make concessions under a joint program in the name of affordability; the question is whether those concessions were made worthwhile by producing an affordable next generation fighter.

The program has been highly successful in its focus for commonality. The ORD called for 70%-90% commonality across the variants. Lockheed Martin reports that current component commonality is at 80%.[48] Whether this commonality has produced an airframe that will produce a next generation fighter for the services that is on schedule and on budget is another issue.

There are many differing opinions on the estimate for a per unit cost of the JSF, but it would be hard to argue that the JSF has achieved its goal of affordability. In 2004, the JSF program was forced to report a Nunn-McCurdy unit cost breach; a requirement for any program that has an increase in unit cost growth of over 30%.[49] The 2006 Defense Department's quarterly Selected Acquisition report estimated that the JSF program would cost $299,824.1 billion (2006 dollars).[50] With a total of 2,458 aircraft being split between the USAF, Department of the Navy, and the United Kingdom, the per unit cost (including research and development) had risen to $121.9 million.[51] If the R&D is removed from the equation the estimate is still staggering at $104.4 million per aircraft. These estimates are 37.9% and 37.7% higher than the original estimates made in 2001.[52]

In 2003 the JSF program conducted a preliminary design review that revealed significant weight related issues that were considered detrimental to its ability to achieve the key performance parameters lay out by the Operational Requirements Document.[53] The majority of the weight-related issues were centered on the Marine Corps STOVL variant.[54] It became necessary to add resources and redesign the USMC variant's weapons bay to address this significant setback. Following the Nunn-McCurdy breach the entire program was rebaselined in 2004. As a result, the program was delayed by one year, total program acquisition costs increased $11.8 billion and the number of aircraft decreased by 409.[55] This resulted in a per unit increase of $19 million. Since the rebaseline in 2004 the program costs have increased an additional $31.6 billion and per unit costs have increased 12%.[56] In total, the JSF program costs have increased by over $100 billion to date. Considering that affordability and "bang for the buck" are touted as the cornerstone of the JSF plan, it is hard to view the financial aspect of the program as anything other than a failure.

Lethality and Survivability

While affordability is the cornerstone of the entire JSF program, certainly technology is the tactical cornerstone. Low observable and stealth technology are expected to compensate for little to no gain over legacy platform performance in providing survivability. Avionics and software technology are intended to provide lethality via complete interoperability with other platforms and the C4ISR architecture. As previously noted, and not withstanding previous arguments over the usefulness of LO and stealth technology, it will be assumed that the JSF program meets its goals in providing an adequate stealth platform. Success in the area of interoperability, however, is debatable.

Interoperability was listed as a *key performance parameter*. This interoperability was seen as so key to the lethality of the JSF that failure to achieve it could be "cause for reassessment or termination of the program."[57] According to a recent Government Accountability Organization (GAO) report, the JSF program has reported that it will meet all its key performance parameters *except* interoperability.[58] Without integration into the C4ISR architecture the JSF will come up short in its goal to significantly increase lethality over legacy platforms. The JSF relies mainly on software for its mission effectiveness. The JSF is estimated to require some 22 million lines of code (6 times the number used by the F-22A).[59] Only 40% of the software has been completed and of that the majority is focused on operating vice mission capabilities.[60] In essence, the program is already $100 billion over budget and has yet to prove its most crucial mission capability will be integrated.

The JSF team learned from the F/A-18 and F-16 that preserving room, power, and cooling for growth and modifications could prove invaluable in the future. The ORD called for this preservation, as well as a hardware and software architecture that would be "modular and scalable to allow ready and affordable insertion of new technologies" with a minimal testing requirement.[61] The program appears to be coming up short in the area of future growth.

First, the quest for Volume and power has failed. It is a known fact that the JSF has weight issues. The extreme weight problems the plagued the STOVL variant likely delayed the program years and increased the budget by tens of billions. In addition, Lockheed Martin has kept a tight lid on the fact that the JSF has come up short on power. In August 2007 the U.S. Department of Defense announced a contract for Hamilton Sundstrand to produce a new power generator to compensate for a 33% power deficit in the JSF.[62] The shortage came as a result of flawed design estimates that failed to take into account that the JSF's hydrostatic actuators used by the flight control system may compete for peak power at the same instant.[63] Clearly, this leaves little to no room for expansion and would require any future modifications to use less or equal power of the current system it would replace.

Second, the JSF seems unlikely to provide a platform that has a hardware and software architecture that would allow the easy addition of any new technologies. The current JSF plan includes over 22 million lines of software code; this is over six times the number in the F-22A.[64] Only 40% of the code has been completed to date, and the program is well into the flight testing phase. According to a European air force employee who works on the JSF team, the code is so far behind that the JSF may not have multi-role capability until 2016 rendering it useless in the air-to-air arena.[65] This does not paint a picture of a system with easily adaptable software, but rather one that will require many "patches" when adding technology.

Supportability

Although the JSF program's success in supportability will be unknown until years after its introduction into the operational world, it appears as if it is on the right track. All the services have asked for significant improvements over legacy platforms through the initiation of a revolutionary *support concept*. Areas addressed were logistics footprint, sortie generation rate (SGR), and reliability and maintainability (R&M).[66] Logistics footprints and sortie completion rate thresholds are vast improvements over their legacy counterparts. These improvements are based on the projected benefits of the currently untested JSF support concept.

The JSF support concept will incorporate with and expand each of the services' logistics infrastructures to properly support their new fighter.[67] The JSF support concept relies on the Autonomous Logistics system to identify maintenance, safety, and training needs.[68] The JSF will use a highly advanced onboard prognostic health management (PHM) system to notify maintainers of necessary maintenance and warn of possible future failures. The PHM system will cover all "mission critical and life limited components so that maintenance is based on actual material condition."[69] This could save hundreds of man hours over a current system that typically ties required maintenance to a specific number of flight hours vice actual component health. Whether this system will be effective remains to be seen, but the concept is a huge step in the right direction.

Chapter 5
Conclusions

The JSF program is attempting to do what no other joint acquisition program has successfully achieved: provide a viable TACAIR platform to three separate services. As previously stated, the program can be commended for learning from the historical mistakes of the TFX program. The *possibility* that was so arrogantly ignored by politicians, engineers, and the services alike, is that it could be inherently impossible to provide three separate services, each with distinct missions, a single platform to suit all their needs. All the forethought, planning, and seemingly small concessions in the world may not be enough to overcome the hurdle of joint TACAIR acquisition. The JSF program, although certainly well intentioned, came up short in many areas that will affect the services and their combat capability for decades to come. Its shortcomings only lend credibility to the idea that joint TACAIR acquisition is not feasible.

We are now thirteen years and billions of dollars into the program. Although the program is an estimated $100 billion over budget and will provide over 500 fewer aircraft, it is certainly too late to pull out now. The result, however, is that no service will be truly receiving the aircraft they need. The USAF desperately needs a replacement for the A-10 to perform its CAS role in support of ground troops. The JSF has no chance of effectively replacing the A-10. The USAF also needs an affordable replacement for its F-16. The JSF will exceed the capability of the F-16 in many areas, but at five times the original cost per unit. Fewer aircraft will be purchased resulting in a less than one for one exchange forcing units to do more with fewer aircraft; a fact that will most likely lead to overworked airframes down the line. The Navy will not be receiving the true fifth generation aircraft it needs. Although the JSF provides a stealth capability it has an inferior weapons loadout and no significant performance improvement when compared to current Navy strike fighters. The USMC will be provided a platform that is already struggling with weight problems and is woefully equipped to perform the Marine Corps' most vital mission of supporting its own troops. It is clear that a combination of the services making the wrong concessions and contractors promising too much will lead to a strike fighter fleet that lacks what its operators truly need.

Whether or not the JSF program could have been successful if services had demanded the proper requirements is questionable. More than likely the services desired the correct capabilities, but were told it was impossible in one airframe. The fact that a joint program was forced on the services is where the problem stemmed from. The inherent give and take in joint acquisition simply does not lend itself well to TACAIR platforms.

A common sense approach to TACAIR acquisition is necessary in the future. There will certainly always be political constraints placed on services seeking new platforms. When attempting to navigate the system leaders must not lose their grasp on common sense. It is clearly not possible to combine the multi-role fighter programs of two services with the STOVL program of a third. Service parochialism must go out the window and the focus must remain on what is truly needed and how it should be built. It is far better to fund three programs responsibly than to attempt to force multiple programs into one. The result has historically been disastrous from both a capability and economic standpoint. The JSF will soon provide the Defense Department a second example of a TACAIR joint acquisition program that failed to deliver on its promise.

Endnotes

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