DCN: 8660

FAS Military Analysis Network

Joint Strike Fighter (JSF)

The Joint Strike Fighter (JSF) is a multi-role fighter optimized for the air-to-ground role, designed to affordably meet the needs of the Air Force, Navy, Marine Corps and allies, with improved survivability, precision engagement capability, the mobility necessary for future joint operations and the reduced life cycle costs associated with tomorrow's fiscal environment. JSF will benefit from many of the same technologies developed for F-22 and will capitalize on commonality and modularity to maximize affordability.

On October 26, 2001, the Defense Department selected Lockheed Martin's F-35 as the winner of the competition to manufacture the Joint Strike Fighter. Click here for more information.

The 1993 Bottom-Up Review (BUR) determined that a separate tactical aviation modernization program by each Service was not affordable and canceled the Multi-Role Fighter (MRF) and Advanced Strike Aircraft (A/F-X) program. Acknowledging the need for the capability these canceled programs were to provide, the BUR initiated the Joint Advanced Strike Technology (JAST) effort to create the building blocks for affordable development of the next-generation strike weapons system. After a review of the program in August 1995, DoD dropped the "T" in the JAST program and the JSF program has emerged from the JAST effort. Fiscal Year 1995 legislation merged the Defense Advanced Research Projects Agency (DARPA) Advanced Short Take-off and Vertical Landing (ASTOVL) program with the JSF Program. This action drew the United Kingdom (UK) Royal Navy into the program, extending a collaboration begun under the DARPA ASTOVL program.

The JSF program will demonstrate two competing weapon system concepts for a tri-service family of aircraft to affordably meet these service needs:

USAF-Multi-role aircraft (primarily air-to-ground) to replace F-16 and A-10 and to complement F-22. The Air Force JSF variant poses the smallest relative engineering challenge. The aircraft has no hover criteria to satisfy, and the characteristics and handling qualities associated with carrier operations do not come into play. As the biggest customer for the JSF, the service will not accept a multirole F-16 fighter replacement that doesn't significantly improve on the original.

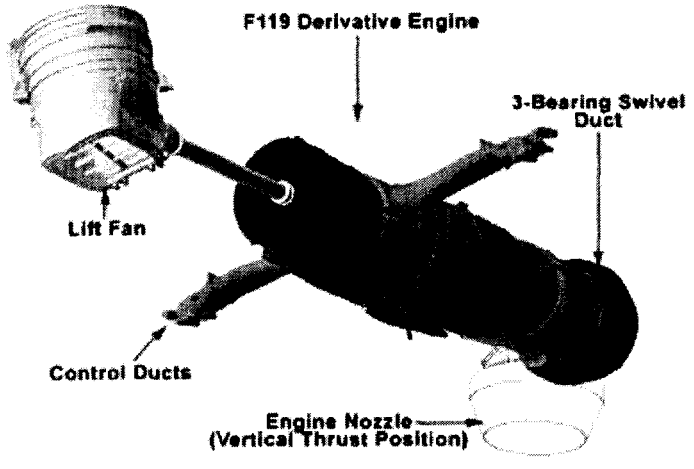
USN-Multi-role, stealthy strike fighter to complement F/A-18E/F. Carrier operations account for most of the differences between the Navy version and the other JSF variants. The aircraft has larger wing and tail control surfaces to better manage low-speed approaches. The internal structure of the Navy variant is strengthened up to handle the loads associated with catapult launches and arrested landings. The aircraft has a carrier-suitable tailhook. Its landing gear has a longer stroke and higher load capacity. The aircraft

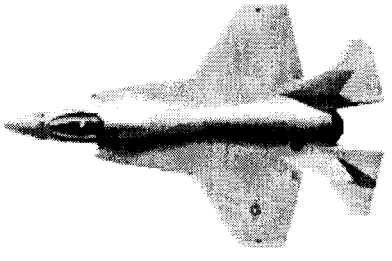
has almost twice the range of an F-18C on internal fuel. The design is also optimized for survivability.

USMC-Multi-role Short Take-Off & Vertical Landing (STOVL) strike fighter to replace AV-8B and F/A-18A/C/D. The Marine variant distinguishes itself from the other variants with its short takeoff/vertical landing capability.

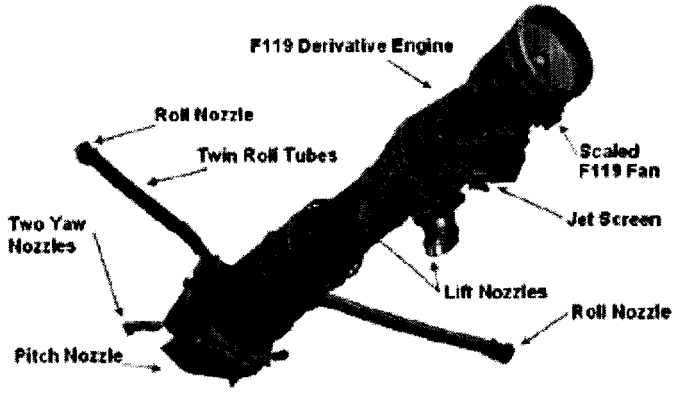
UK-STOVL (supersonic) aircraft to replace the Sea Harrier. Britain's Royal Navy JSF will be very similar to the U.S. Marine variant.

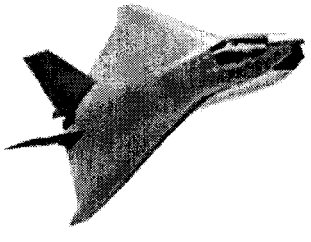
The JSF concept is building these three highly common variants on the same production line using flexible manufacturing technology. Cost benefits result from using a flexible manufacturing approach and common subsystems to gain economies of scale. Cost commonality is projected in the range of 70-90 percent; parts commonality will be lower, but emphasis is on commonality in the higher-priced parts.





The Lockheed Martin X-35 concept for the Marine and Royal Navy variant of the aircraft uses a shaft-driven lift-fan system to achieve Short-Takeoff/Vertical Landing (STOVL) capability. The aircraft will be configured with a Rolls-Royce/Allison shaft-driven lift-fan, roll ducts and a three-bearing swivel main engine nozzle, all coupled to a modified Pratt & Whitney F119 engine that powers all three variants.





The Boeing X-32 JSF short takeoff and vertical landing (STOVL) variant for the U.S. Marine Corps and U.K. Royal Navy employs a direct lift system for short takeoffs and vertical landings with uncompromised up-and-away performance.

Key design goals of the JSF system include:

Survivability: radio frequency/infrared signature reduction and on-board countermeasures to survive in the future battlefield--leveraging off F-22 air superiority mission support

Lethality: integration of on- and off-board sensors to enhance delivery of current and future precision weapons

Supportability: reduced logistics footprint and increased sortie generation rate to provide more combat power earlier in theater

Affordability: focus on reducing cost of developing, procuring and owning JSF to provide adequate force structure

JSF's integrated avionics and stealth are intended to allow it to penetrate surface-to-air missile defenses to destroy targets, when enabled by the F-22's air dominance. The JSF is designed to complement a force structure that includes other stealthy and non-stealthy fighters, bombers, and reconnaissance / surveillance assets.

JSF requirements definition efforts are based on the principles of Cost as an Independent Variable: Early interaction between the warfighter and developer ensures cost / performance trades are made early, when they can most influence weapon system cost. The Joint Requirements Oversight Council has endorsed this approach.

The JSF's approved acquisition strategy provides for the introduction of an alternate engine during Lot 5 of the production phase, the first high rate production lot. OSD is considering several alternative implementation plans which would accelerate this baseline effort.

Program Status

The focus of the program is producing effectiveness at an affordable price—the Air Force's unit flyaway cost objective is $28 million (FY94$). This unit recurring flyaway cost is down from a projected, business as usual,cost of $36 million. The Concept Demonstration Phase (CDP) was initiated in November 1996 with the selection of Boeing and Lockheed Martin. Both contractors are: (1) designing and building their concept demonstration aircraft, (2) performing unique ground demonstrations, (3) developing their weapon systems concepts. First operational aircraft delivery is planned for FY08.

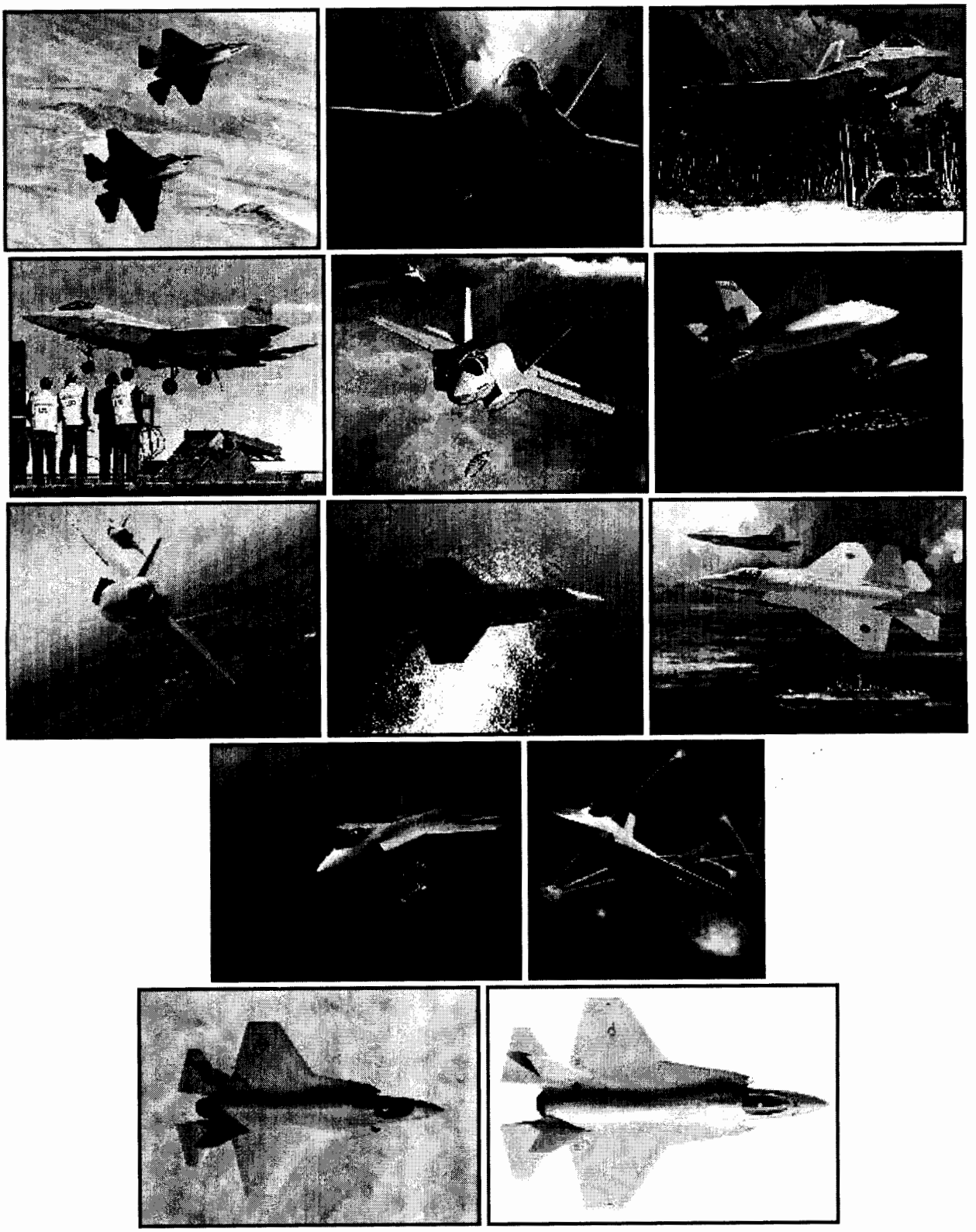
JSF is a joint program with shared acquisition executive responsibilities. The Air Force and Navy each provide approximately equal shares of annual funding, while the United Kingdom is a collaborative partner, contributing $200 million to the CDP. CDP, also known as the Program Definition and Risk Reduction (PDRR) phase, consists of three parallel efforts leading to Milestone II and an Engineering and Manufacturing Development (EMD) start in FY01:

Concept Demonstration Program. The two CDP contracts were competitively awarded to Boeing and Lockheed Martin for ground and flight demonstrations at a cost of $2.2 billion for the 51-month effort, including an additional contract to Pratt & Whitney for the engine. Each CDP contractor will build concept demonstrator aircraft (designated X-32/35). Each contractor will demonstrate commonality and modularity, short take-off and vertical landing, hover and transition, and low-speed carrier approach handling qualities of their aircraft.

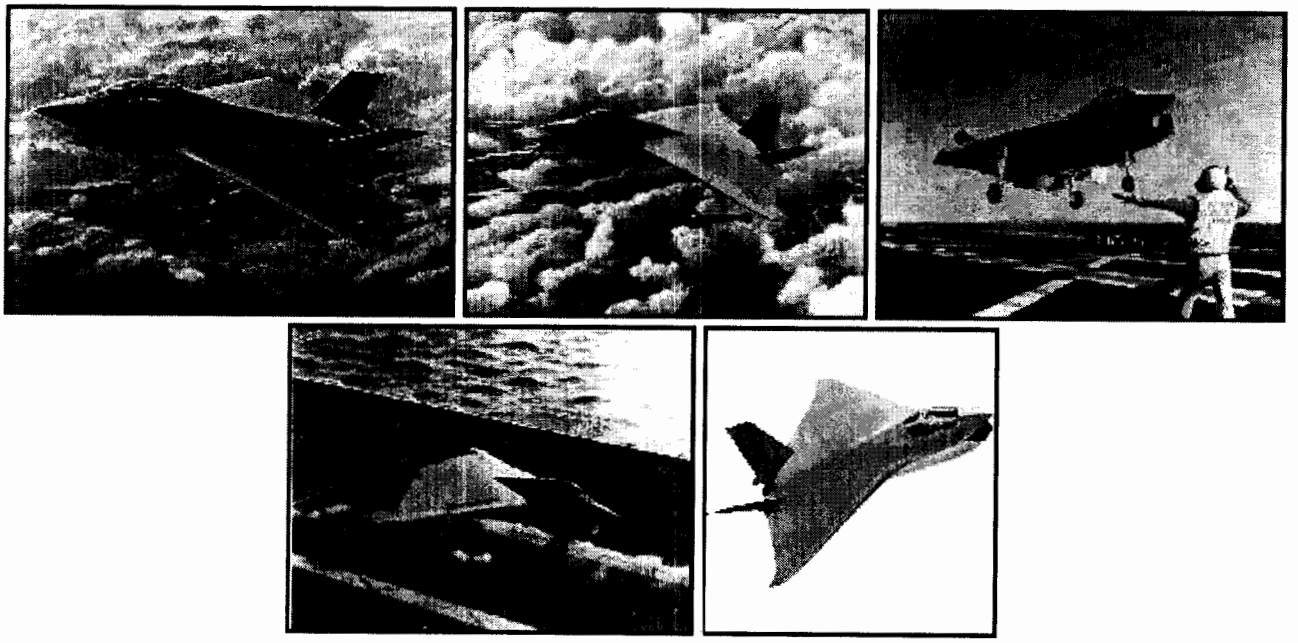
Technology Maturation. These efforts evolve key technologies to lower risk for EMD entry. Parallel technology maturation demonstrations are also an integral part of the CDP / PDRR objective of meeting warfighting needs at an affordable cost. Focus is on seven critical areas: avionics, flight systems, manufacturing and producibility, propulsion, structures and materials, supportability, and weapons. Demonstration plans are coordinated with the prime weapon system contractors and results are made available to all program industry participants.

Requirements Definition. This effort leads to Joint Operational Requirements Document completion in FY00; cost/performance trades are key to the process.

LockMart JSF Design - X-35



Boeing JSF Design - X-35



Specifications

Function	strike fighter		
Contractor	two competing teams: Lockheed-Martin Boeing		
Service	U.S. Air Force	U.S. Marine Corps U.K. Royal Navy	U.S. Navy
Variants	Conventional Takeoff and Landing (CTOL)	Short Takeoff and Vertical Landing (STOVL)	Carrier-based (CV)
Unit Cost FY94$	$28M	$35M	$38M
Propulsion	Baseline: Pratt & Whitney F119-PW-100 derivative from F-22 Raptor Alternate Engine: General Electric F120 core		
Thrust			
Empty Weight	~22,500 lbs		~24,000 lbs
Internal Fuel	15,000 lbs		16,000 lbs
Payload	13,000 lbs		17,000 lbs
Maximum Takeoff Weight	~50,000 lbs		
Length	45 feet		
Wingspan	36 feet		30 feet
Height			
Ceiling			

Speed		supersonic	
Combat Radius		over 600 nautical miles	
Crew		one	
Armament			
First flight		1999	
Date Deployed		2008	
Inventory Objectives	U.S. Air Force 2,036 aircraft	U.S. Marine Corps 642 aircraft U.K. Royal Navy 60 aircraft	U.S. Navy 300 aircraft

Sources and Resources

- Dave Hasting's JSF Page
- Joint Adv Strike Tech Program FY98 R&D Budget Request
- 0603800N JOINT ADVANCED STRIKE JASTP FY98 R&D Budget Request

- The Joint Strike Fighter Derek W. Avance; Christopher S. Ceplecha; Robert E. Clay; Terry M. Featherston; David S. Grantham; Thomas E. Gregory (Faculty Advisor); Patrick A. Kelleher; David Kelly; Thomas L. Moore (Faculty Advisor); Garry L. Pendleton; John Rupp; Christopher E. Yelder *Air Command and Staff College* 1996
- JSF excerpts from House National Security Committee Report on House National Defense Authorization Act for FY 1998
- MEMORANDUM FOR CORRESPONDENTS June 23, 1998 The Joint Strike Fighter program office today announced today that Pratt & Whitney began ground testing the second of two developmental engine designs for the Joint Strike Fighter (JSF) Concept Demonstrator Aircraft (CDA).
- Designing The Next Generation Strike Fighter Brigadier General Leslie Kenne, Director, Joint Strike Fighter Program Office [1500k PDF]
- Boeing Refines Joint Strike Fighter Design February 4, 1999 - Boeing has taken the next step in maturing the design for its Joint Strike Fighter (JSF), improving its affordability, supportability and performance capabilities while maintaining the fundamentals of its original weapon-system concept.
- Joint Strike Fighter concept demonstrators slated to begin flying Air Force Print News 24 May 2000 -- Competitors for the Air Force's newest multi-role aircraft, the Joint Strike Fighter, will begin flying their concept demonstrators in the next few months.
- Joint Strike Fighter Acquisition Strategy, Boeing Press Release, 22 June 2000 -- Boeing supports today's Defense Department announcement confirming the current winner-take-all strategy on the Joint Strike Fighter competition.
- Cohen: Joint Strike Fighter program must stay on schedule, Stars and Stripes, 24 June 2000 -- Defense Secretary William Cohen sent a letter to senior House and Senate lawmakers Thursday urging them to keep the funding and schedule for the Pentagon's Joint Strike Fighter aircraft on schedule.
- First Joint Strike Fighter lands at Edwards, Air Force Print News, 20 September 2000 -- One version of the Joint Strike Fighter program made its first flight early Sept. 18.
- NAVAIR test pilot breaks new ground in JSF testing, NAWCAD Public Affairs, 26 October 2000 -- In what could be the one of the last "first flights" of a new fighter program for a long time, Boeing chief test pilot J. Knox piloted the X-32 Joint Strike Fighter concept demonstrator on its first flight thrilling none more than Navy Cmdr. Phil "Rowdy" Yates.

- The Lockheed Martin Joint Strike Fighter X-35A successfully executed a series of airborne refuelings during its 10th flight, demonstrating the aircraft's flying qualities during refueling and paving the way for extended test flights., Air Force Print News, 15 November 2000 -- The Lockheed Martin Joint Strike Fighter X-35A successfully executed a series of airborne refuelings during its 10th flight, demonstrating the aircraft's flying qualities during refueling and paving the way for extended test flights.
- Boeing X-32A begins simulated carrier-landing tests, Air Force Print News, 17 November 2000 -- The Boeing Joint Strike Fighter X-32A concept demonstrator aircraft began field carrier-landing practice tests Nov. 15 to demonstrate flying and handling qualities during low-speed aircraft carrier approach.
- X-35A breaks sound barrier, Air Force Print News, 27 November 2000 -- With its flight testing now complete, the X-35A returned to Lockheed Martin's nearby Palmdale, Calif., facility to be fitted with a shaft-driven lift-fan propulsion system. It will be renamed the X-35B and will begin ground testing in preparation for its short takeoff/vertical landing demonstrations.
- Navy Variant of Lockheed Martin JSF Takes Flight, Lockheed Martin Press Release, 16 December 2000 -- The United States Navy version of the Lockheed Martin Joint Strike Fighter (JSF) demonstrator took to the skies on Saturday, Dec. 16, initiating a flight-test program that will focus on carrier-suitable flying qualities and aircraft performance.
- Boeing Completes JSF X-32B Engine Accelerated Mission Tests, Boeing Press Release, 15 January 2001 -- Boeing, Pratt & Whitney and Rolls-Royce today completed accelerated mission tests of the Joint Strike Fighter X-32B qualification engine at Pratt & Whitney's facility in West Palm Beach, Fla.
- U.S., U.K. Sign Joint Strike Fighter Agreement Jan. 17, U.S. Department of Defense, 17 January 2001 -- Deputy Defense Secretary Rudy de Leon signed a U.S.-United Kingdom Memorandum of Understanding on the joint strike fighter (JSF) with Baroness Symons of Vernham Dean, U.K. Minister of State for Defence Procurement, in a ceremony at the Pentagon January 17.
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- Boeing Completes JSF X-32B Maximum-Thrust STOVL Engine Runs, Boeing Press Release, 08 March 2001 -- Boeing yesterday completed maximum-thrust engine runs in the short-takeoff-and-vertical-landing (STOVL) mode on its Joint Strike Fighter X-32B concept demonstrator, achieving a major milestone in preparation for first flight.
- Boeing JSF X-32B Completes Successful First Flight, Boeing Press Release, 29 March 2001 -- The Boeing Joint Strike Fighter X-32B demonstrator today successfully completed its first flight, entering a four-month test program to validate the Boeing direct-lift approach to short-takeoff-and-vertical-landing (STOVL) flight.
- Joint Strike Fighter Agreement Signed , DOD News Release, 06 June 2001 -- Officials from Pratt & Whitney (P&W) and GE Aircraft Engines (GEAE) today signed an agreement to work together on the Joint Strike Fighter (JSF) program, to assure that both companies' engines will be physically and functionally interchangeable across all three variants of the JSF aircraft.

- Joint Strike Fighter Homepage - Air Force
- Lockheed Martin JSF Homepage
- Boeing JSF Homepage
- DOD News Briefing -- Joint Strike Fighter Development Selection - Nov. 16, 1996
- Joint Strike Fighter Armed Forces Journal International, February 1996
- Politics could cloud fighter plane's future Fort Worth Star-Telegram (Jun 24, 1996)

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http://www.fas.org/man/dod-101/sys/ac/jsf.htm
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Originally Last Updated April 05, 2005 10:32:50 P.M.

Carroll, Ray, CIV, WSO-BRAC

From: MacGregor, Timothy, CIV, WSO-BRAC
Sent: Wednesday, July 27, 2005 9:12 AM
To: Carroll, Ray, CIV, WSO-BRAC
Subject: Interesting JSF piece

UPDATED: July 27, 2005Full Version
Pentagon may scrap jet plans
BY: Mark Mazzetti, Los Angeles Times*
07/27/2005

WASHINGTON — Facing severe budget pressures, the Pentagon is developing plans to slash the Air Force's two prized fighter jet programs, according to Defense Department officials and outside experts.

Military planners are debating options to scale back the Air Force's F-35 Joint Strike Fighter and the stealth F/A-22 fighter, as some defense officials question spending billions on weapons that have little use against terrorist networks and other unconventional threats.

Such a move would be an enormous blow to the Air Force, which has spent years developing the two weapons to replace its aging fleet of fighter jets. The budget cuts could encounter fierce resistance from lawmakers, including some from California, whose districts would be hit hard by the economic repercussions.

Yet as the Pentagon conducts a top-to-bottom assessment of its entire arsenal, defense officials are mindful that the military buildup that followed Sept. 11 is coming to an end. The war in Iraq, which now costs the Defense Department more than $4 billion per month, is contributing to the budget squeeze that jeopardizes some of the Pentagon's most desired — and expensive — weapons.

The Joint Strike Fighter program is projected to cost $245 billion, a price tag shared by the Air Force, Navy, Marine Corps and nine U.S. allies, including Britain, Canada, Australia, Denmark and Turkey. It is the Pentagon's most expensive weapons program, and the Air Force has by far the largest part of the budget; it hopes to purchase 1,763 of the planes to replace the F-16 fighter.

The Air Force also plans to acquire 179 F/A-22s, each costing about $345 million.

A Pentagon decision to scale back the programs would be the strongest signal yet of a significant change in strategic priorities. With Defense Secretary Donald H. Rumsfeld trying to transform the military to deal with unconventional threats, many say that weapons built for dogfights and eluding enemy radar are increasingly irrelevant.

"What does Al Qaeda's air force look like?" said one defense official working on the Pentagon's assessment, known as the Quadrennial Defense Review.

The Pentagon's overall budget is expected to grow by 8% between now and the end of fiscal year 2011. Yet with the military planning to field about a dozen big-ticket planes, ships and submarines during that period, the Pentagon estimates that its budget for new weapons will balloon by 34%.

Some of these weapons, such as the Army's Future Combat System — a fleet of combat vehicles linked to a computer network — and the Navy's DDX destroyer, are being eyed for cutbacks to prevent a budget crisis later.

Because U.S. troops are heavily engaged in the Middle East and Central Asia, officials say there is little room to cut personnel costs from the Pentagon budget. Weapons, they say, are the only target for cost reductions.

Although Pentagon officials contend that no final decision has been made about the fate of the two Lockheed Martin-designed jets, some inside the Defense Department say that the deepest cuts could come in the Joint Strike Fighter program. According to one source, the Pentagon could cut the Air Force's allotment of the planes by half.

Officials involved in the review process say that the option of canceling one or both of the programs is on the table, although it is extremely unlikely — in part because such a move would cause a furor among members of Congress. The

fact that close allies are involved in developing the JSF is another factor that should keep the program alive, the officials say.

Although Lockheed is the prime contractor for both jets, about 40% of the JSF is assembled at Northrop Grumman Corp.'s plant in Palmdale. Most of the F/A-22 is built at Lockheed's plant in Marietta, Ga.

Pentagon spokesman Lawrence DiRita said it was too early in the review process to know what specific programs might be cut or expanded, and that planners were still identifying which types of missions the military ought to be preparing for.

"It's definitely premature to say we're looking at cuts," said DiRita, who stressed that there were months remaining in the review — due before Congress by early February — and that no proposals had been presented to Rumsfeld.

He did say that Pentagon officials hoped to make some decisions about weapons programs by September or October, as the Defense Department prepared its fiscal year 2007 budget.

The Joint Strike Fighter and the F/A-22 have been plagued by cost overruns and production delays. In April, the Government Accountability Office called the JSF's original business case, laid out by the Pentagon in 1996, "unexecutable."

"When you have difficult budget choices to make, several of the Pentagon's expensive modernization programs become likely targets," said Andrew Krepinevich of the Center for Strategic and Budgetary Assessments in Washington.

"The JSF sits at the top of that list."

Air Force officials are vigorously lobbying to preserve their coveted weapons, and supporters of the two programs point out that the emergence of China as a potential long-term threat is the best case for a large investment in fighter jet technology.

Last week, a Pentagon report warned that China's military buildup threatened the balance of power in Asia, and that within a decade China's military could pose a threat to modern militaries on the continent.

Air Force officials, who consider protecting the F/A-22 their top priority during the review process, argue that the jet's stealth technology makes it essential for eluding the advanced radar systems the Chinese are developing.

The Pentagon has scaled back the number of F/A-22 jets it intends to buy from 381 aircraft to 179. But Pentagon officials say that deeper cuts in the number of planes purchased are possible.

Rumsfeld has repeatedly criticized the length of time it can take for a weapon to move from the drawing board to operational testing to deployment in the field.

"There's no question that the longer it takes to field a program, the more expensive it becomes," DiRita said.

The Pentagon has billed the 2005 Quadrennial Defense Review as a crucial step in the long-term effort to transform the military into a lighter, more agile fighting force.

As defense officials try to predict the types of threats U.S. forces will confront, they face hard choices about spending billions on weapons that in most cases were first envisioned during the Cold War.

Many defense experts point out that the success of Iraqi insurgents against U.S. troops is evidence that few enemies will choose to fight the U.S. military on the conventional battlefield.

Instead of buying expensive technology, they point out, the future of warfare requires that the Pentagon invest in counterinsurgency warfare and bulk up spending on armored vehicles, language training and civil affairs programs.

"The big cuts in fighters being considered are just one instance of a far broader rethinking in the Pentagon spending priorities," said Loren Thompson of the Lexington Institute, a defense think tank in Arlington, Va. "Much of the impetus for these cuts originated in the Iraqi insurgency and in the need to wage a protracted war against terror."

Vulnerable birds

A look at the two fighter jets that may have their budgets cut in a cost-cutting plan by the Defense Department; both jets are in production and not yet in use:

F-35 Joint Strike Fighter

Users: Air Force, Navy and Marines, and some foreign militaries

Schedule: Test flights are to begin in 2006.

Program cost: $245 billion

Contractors: Lockheed Martin Corp., main prime contractor. Northrop Grumman Corp. and BAE Systems, principal partners.

Manufacturing locations: Center fuselage by Northrop Grumman in Palmdale and El Segundo. Final assembly by Lockheed Martin in Fort Worth.

F/A-22 Raptor

Users: Air Force

Schedule: To be operational by the end of the year.

Program cost: $64 billion

Contractors: Boeing Co. and Lockheed Martin Corp.

Manufacturing locations: Wings and aft fuselage by Boeing in Seattle. Final assembly by Lockheed Martin in Marietta, Ga.

Sources: U.S. Air Force, Airforce-Technology.com, Boeing

United States Government Accountability Office

GAO

Testimony
Before the Subcommittee on AirLand, Committee on Armed Services, U.S. Senate

For Release on Delivery
Expected at 2:30 p.m. EDT
Wednesday, April 6, 2005

TACTICAL AIRCRAFT

F/A-22 and JSF Acquisition Plans and Implications for Tactical Aircraft Modernization

Statement of Michael Sullivan, Director
Acquisition and Sourcing Management Issues

April 6, 2005

GAO
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Highlights

Highlights of GAO-05-519T, a testimony before the Subcommittee on AirLand, Committee on Armed Services, U.S. Senate

TACTICAL AIRCRAFT

F/A-22 and JSF Acquisition Plans and Implications for Tactical Aircraft Modernization

Why GAO Did This Study

The F/A-22 Raptor and Joint Strike Fighter (JSF)—two of the Department of Defense's (DOD) major tactical aircraft fighter programs—are intended to replace aging tactical fighter aircraft with highly advanced, stealthy aircraft. The two programs combined have a potential future investment of more than $240 billion.

This testimony highlights key concerns in the F/A-22 and JSF programs and discusses the implications on DOD's overall investment strategy for modernizing its tactical fixed-wing aircraft. Last month, GAO issued comprehensive reports on the numerous setbacks these programs have experienced since they were initiated and their effect on the F/A-22 and JSF business cases.

What GAO Recommends

GAO made recommendations in two reports issued in March 2005. For the F/A-22 program, GAO reiterated and expanded upon its 2004 recommendation for DOD to establish a new business case—one that justifies the continued expenditure of funds on the F/A-22. For the JSF program, GAO recommended that—before the program moves forward—DOD establish an executable business case that is consistent with best practices and DOD policy regarding knowledge-based, evolutionary acquisitions.

www.gao.gov/cgi-bin/getrpt?GAO-05-519T

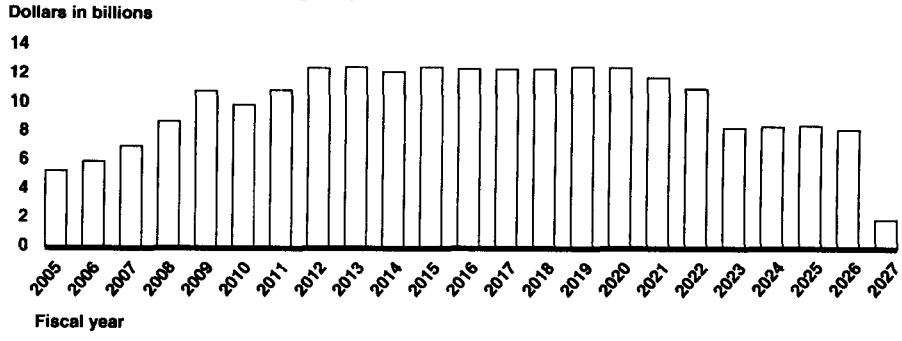
To view the full product, including the scope and methodology, click on the link above. For more information, contact Michael J. Sullivan at (202) 512-4841 or sullivanm@gao.gov.

What GAO Found

Significant changes in the F/A-22 program have severely weakened its original business case. Since the F/A-22 program began in 1986, new threats emerged and mission requirements changed; to keep the F/A-22 viable, the Air Force has planned for large investments in new capabilities. Significant delays and cost increases have affected affordability, reducing planned deliveries from 750 F/A-22 aircraft to fewer than 180. The recent budget decision to terminate procurement of the F/A-22 after fiscal year 2008 and the prospect of additional funding cuts also have significant implications for the program's viability and modernization efforts.

JSF's original business case, established when the program began in 1996, is unexecutable. The cost estimate to develop the aircraft has increased 80 percent, operational capability has been pushed out 2 years, and expected acquisition quantities have been cut by 535 aircraft. The JSF program is approaching key investment decisions that will greatly influence the efficiency of the remaining funding—more than 90 percent of the $245 billion estimated total program costs. This sizable investment greatly raises the stakes to meet future promises. While DOD has been working to resolve early design and performance problems, continuing program uncertainties suggest DOD could use more time to gain knowledge before it commits to a new business case and moves forward. To reduce the risk of further cost and schedule growth, any new business case must include an acquisition strategy that adopts an evolutionary, knowledge-based approach to product development. Currently, the JSF program plans to make key production decisions before critical knowledge is captured.

JSF Program's Annual Funding Requirements from 2005 to 2027



Source: GAO analysis of DOD data.

Taken together, these issues have broader implications for the DOD tactical fixed-wing aircraft modernization program, raising questions as to whether overarching goals to reduce average aircraft age and ownership costs while maintaining the force structure are now achievable. The 2005 Quadrennial Defense Review provides an opportunity for DOD to assess needs and plans and to weigh options for accomplishing its tactical aircraft goals.

Mr. Chairman and members of the subcommittee:

I am pleased to be here today to participate in the Subcommittee's hearing on the status of two of the Department of Defense's (DOD) major tactical aircraft fighter programs, the F/A-22 Raptor and the F-35, also known as the Joint Strike Fighter (JSF).[1] Both programs are intended to replace aging tactical fighter aircraft with highly advanced, stealthy aircraft. These two programs represent a potential future investment for DOD of about $240 billion to modernize tactical fixed-wing aircraft.

My statement today will highlight key concerns in the F/A-22 and JSF programs. Our work has shown that because of the significant changes in the F/A-22 development and procurement programs and the key investment decisions remaining, a new business case is needed to justify aircraft quantities and investments in new capabilities. Changes in the JSF program and DOD's intent to begin producing aircraft with at least 6 years of development remaining suggest that the JSF does not yet have the knowledge to justify future investments. In addition to highlighting specific F/A-22 and JSF program issues, I will discuss the implications these development programs have on DOD's overall investment strategy for modernizing the tactical fixed-wing aircraft.

My statement is primarily based on our recent reports on the F/A-22 and JSF programs.[2] We performed the work associated with this statement in accordance with generally accepted government auditing standards.

Summary

The F/A-22 has been in development for 19 years, and cost increases and delays have created affordability concerns that reduced the number of aircraft planned for acquisition. A changing world environment and threats over this time frame have compelled the Air Force to plan for large investments in new capabilities to keep the F/A-22 viable. Termination of F/A-22 procurement after fiscal year 2008 has also placed modernization

[1]The third major program, the FA-18EF, currently in production, is not a subject of this testimony.

[2]GAO, *Tactical Aircraft: Status of the F/A-22 and JSF Acquisition Programs and Implications for Tactical Aircraft Modernization*, GAO-05-390T (Washington, D.C.: Mar. 3, 2005; GAO, *Tactical Airlift: Air Force Still Needs Business Case to Support F/A-22 Quantities and Increased Capabilities*, GAO-05-304 (Washington, D.C.: Mar. 15, 2005); and GAO *Tactical Aircraft: Opportunity to Reduce Risks in the Joint Strike Fighter Program with Different Acquisition Strategy*, GAO-05-271 (Washington, D.C.: Mar. 15, 2005).

plans in doubt. The original business case elements—needs and resources—set at the outset of the program are no longer valid, and a new business case is needed to justify future investments for aircraft quantities and modernization efforts. The F/A-22's acquisition approach was not knowledge-based or evolutionary. It attempted to develop revolutionary capability in a single step, causing significant technology and design uncertainties and, eventually, significant cost overruns and schedule delays. Lessons from the F/A-22 program can be applied to the JSF program to improve on its outcomes.

While relatively early in its acquisition program, the JSF program has experienced design and weight problems that, if not solved, will affect aircraft performance. These problems have led to increased development and procurement costs and schedule delays so far. In addition, the program's customers are still not sure how many aircraft they will need. The combination of cost overruns and quantity reductions has already diluted DOD's buying power and made the original JSF business case unexecutable. Given continuing program uncertainties, DOD could use more time right now to gain knowledge before it commits to a new business case for its substantial remaining investments. The JSF's current acquisition strategy does not embrace evolutionary, knowledge-based techniques intended to reduce risks. Key decisions, like the planned 2007 production decision, are expected to occur before critical knowledge is captured. Time taken now to gain knowledge will avoid placing sizable investments in production capabilities at risk to expensive changes.

Taken together, the current status and continuing risk in these two programs have broader implications to the DOD tactical fixed-wing aircraft modernization program, raising questions as to whether its overarching goals are now achievable. Decreases in quantities alone—about 30 percent since original plans—raise questions about how well the aircraft will complement our tactical air forces in the future.

Background

The F/A-22 aircraft program is acquiring the Air Force's next generation, multimission fighter for about $63.8 billion.[3] The continued need for the F/A-22, its increasing costs, and the quantities required to perform its

[3]This amount consists of $61.3 billion currently budgeted for the basic program and the initial stages of the modernization efforts, $1.3 billion for future start-up costs of a separate acquisition program for the latter stages of modernization, and $1.2 billion in costs to retrofit aircraft with enhanced capabilities and activate depot maintenance activities.

mission have been the subject of a continuing debate within DOD and Congress. Supporters cite the F/A-22's advanced features—stealth, supercruise speed, maneuverability, and integrated avionics—as integral to the Air Force's Global Strike initiative and for maintaining air superiority over potential future adversaries for years to come.[4] Critics, on the other hand, argue that the Soviet threat the F/A-22 was originally designed to counter no longer exists and that its remaining budget dollars could better be invested in enhancing current air assets and acquiring new and more transformational capabilities that will allow it to meet evolving threats. The debate continues as a December 2004 budget decision by the Office of the Secretary of Defense (OSD) reduced F/A-22 funding and the number of aircraft to be acquired. A full-rate production decision is expected in early April, but the Air Force already has 98 aircraft on contract.[5]

The JSF program is DOD's most costly aircraft acquisition program. The program's goals are to develop and field more than 2,400 stealthy strike fighter aircraft for the Navy, Air Force, and Marine Corps and potentially several hundred more aircraft for U.S. allies. International participation in the development of this system is a vital part of the acquisition strategy. The JSF is intended to provide greater capability and to replace DOD's aging fighter and attack aircraft. DOD estimates that the total cost to develop and procure its fleet of aircraft will reach $245 billion, with total costs to maintain and operate the JSF adding another $344 billion over its life cycle. Since the program began in November 1996, it has experienced technical challenges that have resulted in significant cost increases and schedule overruns. During most of 2004, the program worked to understand and define current development risks in order to prepare more accurate cost and delivery estimates to support development and production investment decisions planned over the next 2 years.

A key to successful acquisition programs is the development of a business case that should match requirements with resources—proven technologies, sufficient engineering capabilities, time, and funding—when

[4]Global Strike is one of six complementary concepts of operations laying out the Air Force's ability to rapidly plan and deliver limited-duration and extended attacks against targets.

[5]The Defense Acquisition Board met in late March of this year to discuss the F/A-22's progress and readiness for full-rate production. A final decision by the milestone decision authority is expected in early April.

undertaking a new product development. First, the user's needs must be accurately defined, alternative approaches to satisfying these needs must be properly analyzed, and quantities needed for the chosen system must be well understood. The developed product must be producible at a cost that matches the users' expectations and budgetary resources. Finally, the developer must have the resources to design and deliver the product with the features that the customer wants and to deliver it when it is needed. If the financial, material, and intellectual resources to develop the product are not available, a program incurs substantial risk in moving forward.

A New Business Case Is Needed to Justify Continued Investment in the F/A-22 Program

Since its inception in 1986, the F/A-22 aircraft program has encountered numerous and continuing management and technical challenges. Changing threats, missions, and requirements have severely weakened the original business case. Program milestones have slipped substantially; development costs have more than doubled; and a modernization program was added. The recent budget decision to terminate procurement after fiscal year 2008, the prospect of additional cuts because of ceilings on program cost, and upcoming defense reviews have significant implications for the program's viability and the future of modernization efforts.

In March 2004, we reported that the significant changes in the F/A-22's cost, quantity, capabilities, and mission and the persistent problems and delays in its development and testing schedules called for a new business case to justify the continued need for the F/A-22.[6] We recommended that OSD direct the Air Force to consider alternatives and examine the constraints of future defense spending. In subsequent testimony, we reiterated this position, stating that competing priorities—both internal and external to DOD's budget—require a sound and sustainable business case for DOD's acquisition programs based on comprehensive needs assessments and a thorough analysis of available resources.[7] In response to our recommendation, DOD stated its routine budgeting processes annually addressed business case issues on the F/A-22. We disagreed, as we do not think those processes provide the breadth or depth of analysis needed to develop a comprehensive new business case.

[6]GAO, *Tactical Aircraft: Changing Conditions Drive Need for New F/A-22 Business Case*, GAO-04-391 (Washington, D.C.: Mar. 15, 2004).

[7]GAO, *Tactical Aircraft: Status of the F/A-22 and Joint Strike Fighter Programs*, GAO-04-597T (Washington, D.C.: Mar. 25, 2004).

Problems in the F/A-22 Program Strain Future Viability

When initiated, the F/A-22 acquisition program planned to complete development in 1995, achieve initial operational capability by March 1996, and ultimately procure 750 aircraft. The Air Force currently plans to complete system development in 2005, achieve initial operational capability by December 2005, and procure 178 aircraft.

Amidst concerns about escalating costs and schedule, the Congress placed cost limitations on both development and production budgets in 1997,[8] later removing the development cost cap.[9] According to the Air Force, the current production cost cap is $37.3 billion. Affordability concerns have, in part, led to the steady decrease in procurement quantities. Two major reviews of defense force structure and acquisition plans—the 1993 Bottom-Up Review and the 1997 Quadrennial Defense Review (QDR)—significantly reduced F/A-22 quantities. OSD's "buy to budget" acquisition strategy essentially placed a ceiling on total program costs resulting in reducing quantities, and in December 2004, Program Budget Decision 753 reduced F/A-22 funding by $10.5 billion, further reducing in all likelihood procurement quantities from 275 to 178 aircraft.[10] The December 2004 budget decision also ended procurement in fiscal year 2008, instead of fiscal year 2011.

Decreased procurement quantities, along with increased development and production costs and increased costs to modernize and enhance capability, have led to rising acquisition unit costs. Figure 1 illustrates the downward trend in procurement quantities and the upward trend in program acquisition unit costs.[11]

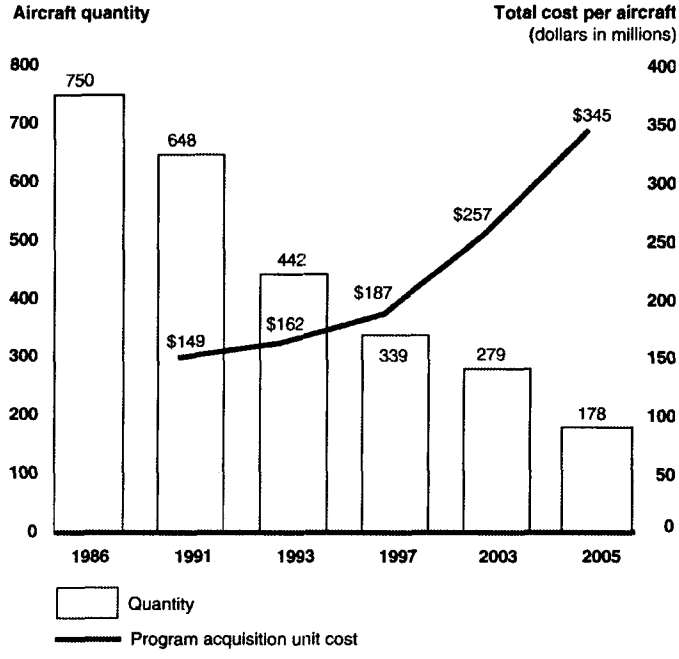
[8]Pub. L. No. 105-85 (Nov. 18, 1997), section 217.

[9]Pub. L. No. 107-107 (Dec. 28, 2001), section 213.

[10]Program Budget Decision 753 nominally reduced the procurement quantity to 179 aircraft. Subsequently, the Air Force transferred one aircraft to be used as a permanent test bed, reducing the procurement quantity to 178. The recent crash of an F/A-22 has reduced planned operational aircraft to 177.

[11]Program acquisition unit cost includes funding for development, procurement, related military construction, and initial modernization divided by total production quantity. It does not include later stage modernization costs and certain support costs.

Figure 1: Quantity and Program Acquisition Unit Cost of F/A-22s



Source: U.S. Air Force (data); GAO (presentation).

In arguing for reversal of the December 2004 budget decision to stop procurement of the F/A-22 in 2008, Air Force officials noted that the decision obviates production economies and efficiencies that the Air Force expected to achieve through a multiyear procurement contract that was to begin in fiscal year 2008. Officials also stated that cutting production quantities from the final years of the program limits expected savings in annual unit procurement costs. As with many DOD acquisitions, Air Force program officials had assumed in future budgets that the costs for buying F/A-22s would decrease as a result of manufacturing efficiencies, reduced fixed costs, productivity projects, and more economical buying quantities. For example, the average unit flyaway cost for the F/A-22 in 2003 was about $178 million, while the unit flyaway costs for future annual buys were projected before the budget decision to decrease to $127 million, $111 million, and $108 million in fiscal years

2007, 2008, and 2009 respectively.[12] Now that the program will be truncated in 2008, the less expensive aircraft in 2009 and beyond will not be bought and unit costs are now projected at $135 million in 2007 and $149 million in 2008 (increases associated with close-out of production).

The F/A-22 program changes have also resulted in schedule delays for completing development testing, operational testing, and, consequently, the full-rate production decision. That decision is currently expected later this month but could slip again given the unsettled environment. One critical input to the decision is the report by the Office of the Director of Operational Test and Evaluation to the Congress and defense leadership on the adequacy and results of the recently completed initial operational test and evaluation.[13] In addition, the F/A-22 program must demonstrate it satisfies criteria established by the Defense Acquisition Board in November 2004, which include delivering a fully resourced plan for follow-on testing to correct deficiencies identified in initial operational testing and evaluation, achieving design stability of the avionics software, demonstrating mature manufacturing processes, and validating technical order data.[14]

Final reports detailing the results from initial operational testing and evaluation were not available for our review, but Air Force test officials told us that testing showed the F/A-22 was "overwhelmingly effective" as an air superiority fighter and that its supporting systems were "potentially suitable" pending the correction of identified deficiencies. Operational testing of the limited ground attack capability in the current design was not conducted but is scheduled during follow-on testing planned to start in

[12]Average unit flyaway cost includes the costs associated with procuring one aircraft, including the airframe, engines, avionics, other mission equipment, and certain nonrecurring production costs. It does not include "sunk" costs for development and test and other costs to the whole system, including logistical support and construction.

[13]Statute 10 U.S.C. 2399 provides that a major defense acquisition program may not proceed beyond low-rate initial production until initial operational test and evaluation is completed and the congressional defense committees have received the report of testing results from the Director of Operational Test and Evaluation. This report is to contain an opinion of test adequacy and whether the test results confirm that the system actually tested is operationally effective and suitable for combat.

[14]The F/A-22 initial operational test and evaluation was conducted by the Air Force Operational Test and Evaluation Center from April through December 2004 to support the full-rate production decision. Its operational test plan was designed to assess the F/A-22's combat effectiveness and suitability in an operationally representative environment.

July 2005.[15] Air Force officials believe that test results support approval of full-rate production. They also believe that deficiencies identified in aircraft reliability and maintainability (including maintaining low observable characteristics) and in the integrated diagnostic systems are readily correctible and the aircraft should meet the needs of the warfighter by the scheduled initial operational capability date in December 2005. However, whether the Air Force can accomplish all of this by December 2005 remains to be seen.

Future of Modernization Plans in Doubt

Originally, the F/A-22 was intended to replace the F-15 and achieve air-to-air superiority to counter large numbers of advanced Soviet fighters in conventional warfare. However, over the 19 years that the aircraft has been in development, the projected Cold War threats never materialized and new threats emerged, changing tactical fighter requirements and operational war plans. The Air Force now plans to implement a Global Strike concept of operations by developing a robust air-to-ground attack capability to allow the aircraft to counter a greater variety of targets, such as surface-to-air missiles systems, that pose a significant threat to U.S. aircraft. It also plans to equip most of the F/A-22 fleet with improved capabilities to satisfy expanded warfighter requirements and to take on new missions, including intelligence data gathering and the suppression of enemy air defenses and interdiction.

To implement its Global Strike concept, the Air Force established a time-phased modernization program. Table 1 shows how the Air Force intended to integrate new capabilities incrementally before the December 2004 budget decision reduced quantities by 96 aircraft. At the time of our review, officials were still determining the impacts of the budget decision on the modernization program content and quantities.

[15]Air-to-ground attack capabilities are increasingly emphasized by the Air Force, and future enhancements are planned for 80 percent of the modernized F/A-22s. More robust ground attack and intelligence gathering capabilities will be tested in the future as they are developed.

Table 1: Planned Modernization Enhancements for the F/A-22 Program

	Fiscal year when enhancements are expected to be incorporated			
	2007	2011[a]	2013	2015
Capabilities increment	Global Strike Basic	Global Strike Enhanced	Global Strike Full	Enhanced Intelligence, Surveillance, and Reconnaissance
Configuration[b]	Block 20	Block 30	Block 40	Block 40
Quantity of F/A-22s	56	91	128	-[c]
Examples of enhancements to be added	Improve capability to launch Joint Direct Attack Munition at faster speeds and at longer distances; upgrade air-to-air capabilities	Enhance air-to-ground capability by adding improved radar capabilities to seek and destroy advanced surface-to-air missile systems; integrate additional air-to-ground weapons	Increase capability to suppress or destroy the full range of air defenses and improve speed and accuracy of targeting	Add capability for full intelligence, surveillance, and reconnaissance integration for increased target sets and lethality

Sources: Air Force and Office of Secretary of Defense.

[a]Global Strike Enhanced includes two increments of capability, with the first increment incorporated in fiscal year 2009 and the second in 2011.

[b]The Air Force planned to have three configurations (called blocks) that included specific enhancements developed in the modernization program.

[c]This quantity included in Global Strike Full amount. Total 128 aircraft planned for block 40.

In March 2003, OSD's Cost Analysis Improvement Group (CAIG) estimated that the Air Force would need $11.7 billion for the planned modernization programs through fiscal year 2018.[16] The Air Force's latest estimate includes about $4.1 billion through fiscal year 2011 for the first two modernization increments (blocks 20 and 30) and about $1.3 billion through fiscal year 2011 for the latter two increments (block 40). The Air Force will continue to manage blocks 20 and 30 as part of the F/A-22 acquisition program. To manage block 40 efforts, OSD has directed the Air Force to establish a separate modernization program.[17] Future modernization costs beyond 2011 have not been fully definitized and are

[16]The OSD CAIG acts as the principal advisory body to the milestone decision authority on program cost. The CAIG estimate included costs for development, procurement, and retrofit of modernized aircraft.

[17]In November 2004, the acting Under Secretary of Defense for Acquisition, Technology and Logistics directed the Air Force to hold separate milestone reviews for the latter stages of the modernization program to be consistent with DOD acquisition policy. The Air Force plans to manage these efforts as a separate acquisition program.

subject to change. The modernization program manager projected annual funding of $700 to $750 million would be needed for the currently planned modernization program after 2011.

The December 2004 budget decision places much of the modernization program in doubt, particularly the latter stages. This is because that decision terminated F/A-22 procurement after fiscal year 2008 and many of these new and advanced capabilities had been planned for aircraft that now will not be bought. Therefore, if the budget cut is sustained, the modernization program as currently planned is largely obsolete and some funding for advanced capabilities planned to be incorporated after fiscal year 2008 could be available for other uses. At the time of our review, Air Force officials were still restructuring the modernization program in response to the budget decision, including revising the desired mix of capabilities and the number of aircraft in each configuration. With the reduced quantity, they are considering having only two configurations, with the second incorporating some enhancements originally planned for the third configuration.

The budget decision causes a ripple effect on other resource plans tied to the modernization. For example, it brings into question the need for (1) upgrades to the computer architecture and processors estimated to cost between $400 million and $500 million; (2) upgrades to government laboratory and test range infrastructure like software avionics integration labs, flying test beds, and test ranges estimated to cost about $1.8 billion; and (3) changes in other activities supporting modernization enhancements in the production line, retrofit of aircraft, and establishing depot maintenance support estimated at more than $1.6 billion.

New JSF Business Case and Acquisition Strategy Is Critical for Program Success

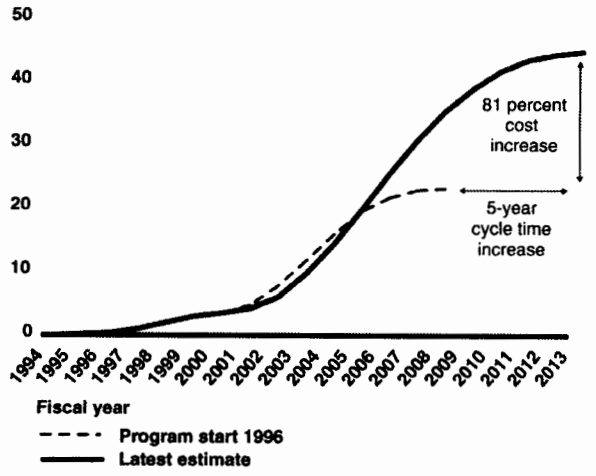
Unlike the F/A-22 program, which is near the end of development, the JSF program is approaching key investment decisions that will greatly influence the efficiency of the remaining funding—over 90 percent of the $245 billion estimated total program costs—and determine the risk DOD is willing to accept. DOD has not been able to deliver on its initial promise, and the sizable investment greatly raises the stakes to meet future promises. Given continuing program uncertainties, DOD could use more time to gain knowledge before it commits to a new business case and moves forward. Any new business case must be accompanied by an acquisition strategy that adopts an evolutionary approach to product development—one that enables knowledge-based decisions to maximize the return on remaining dollars—as dictated by best practices.

DOD Needs More Time to Develop a New JSF Business Case

Increased program costs, delayed schedules, and reduced quantities have diluted DOD's buying power and made the original JSF business case unexecutable. Program instability at this time makes the development of a new and viable business case difficult to prepare. **The cost estimate to fully develop the JSF has increased by more than 80** percent. Development costs were originally estimated at roughly $25 billion. By the 2001 system development decision, these costs increased almost $10 billion, and by 2004, costs increased an additional $10 billion, pushing total development cost estimates to nearly $45 billion. Current estimates for the program acquisition unit cost are about $100 million, a 23 percent increase since 2001. Ongoing OSD cost reviews could result in further increases to the estimated program cost. At the same time, procurement quantities have been reduced by 535 aircraft and the delivery of operational aircraft has been delayed. Figure 2 shows how costs, quantities, and schedules have changed since first estimates based on data as of January 2005.

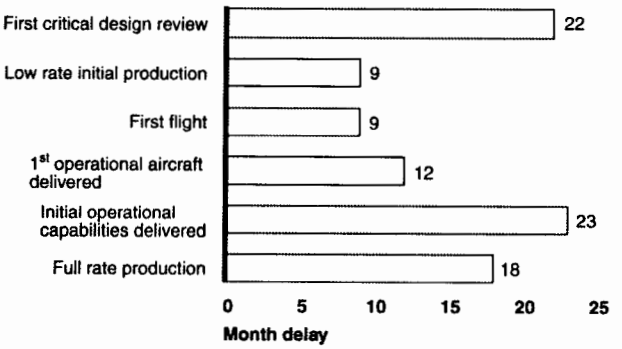
Figure 2: Measures of JSF Cost and Schedule Changes

Development costs and cycle time have increased



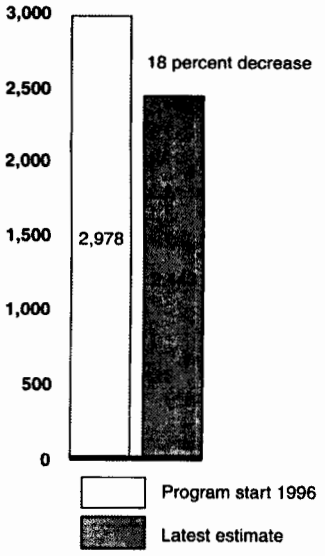
Source: GAO analysis of DOD data.

Key events delayed since development start in 2001



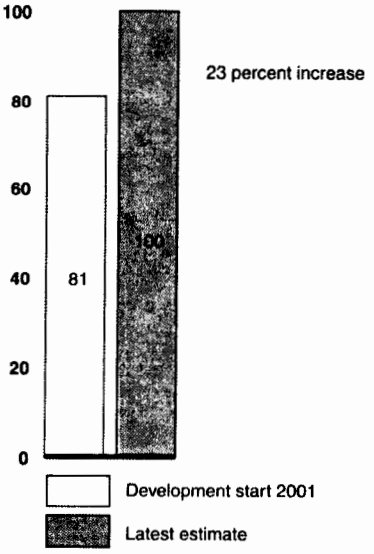
Source: GAO analysis of DOD data.

Procurement quantities have decreased



Source: GAO analysis of DOD data.

Total program acquisition unit costs have increased



Source: GAO analysis of DOD data.

Ongoing program uncertainties—including uncertainties about the aircraft's design and procurement quantities—make it difficult to understand what capabilities can be delivered with future investments. For example, DOD has been working over the past year to restructure the JSF program to accommodate changes in the aircraft's design; until this restructuring is completed, it will be difficult to accurately estimate program costs. The need for design changes largely resulted from the increased weight of the short takeoff and vertical landing variant and the impact it was having on key performance parameters. The other JSF variants' designs were affected as well. The program plans to have a more comprehensive cost estimate in the spring of 2005. However, a detailed assessment has not been conducted to determine the impact that the restructured program will have on meeting performance specifications. Until the detailed design efforts are complete—after the critical design review in February 2006—the program will have difficulty assessing the impact of the design changes on performance. While the program office anticipates that recent design changes will allow the aircraft to meet key performance parameters, it will not know with certainty if the weight problems have been resolved until after the plane is manufactured and weighed in mid-2007.

Program officials are also examining ways to reduce program requirements while keeping cost and schedules constant. Design and software teams have found greater complexity and less efficiency as they develop the 17 million lines of software needed for the system. Program analysis indicated that some aircraft capabilities will have to be deferred to stay within cost and schedule constraints. As a result, the program office is working with the warfighters to determine what capabilities could be deferred to later in the development program or to follow-on development efforts while still meeting the warfighter's basic needs. It may be some time before DOD knows when and what capabilities it will be able to deliver. The content and schedule of the planned 7-year, 10,000-hour flight test program is also being examined. According to the program office, the test program was already considered aggressive, and recent program changes have only increased the risks of completing it on time.

Finally, uncertainty about the number and mix of variants the services plan to purchase will also affect JSF's acquisition plans. While the Air Force has announced its intention to acquire the short takeoff and vertical-landing variant, it has yet to announce when or how many it expects to buy or how this purchase will affect the quantity of the conventional takeoff and landing variant it plans to buy. The number and mix of JSF variants that the Navy and Marine Corps intend to purchase—and their

related procurement costs—also remain undetermined. Foreign partners have expressed intent to buy about 700 aircraft between 2012 and 2015, but no formal agreements have been signed at this time. The 2005 Quadrennial Defense Review—an examination of U.S. defense needs—could also affect the procurement quantities and schedule. In developing a reliable business case, knowing the quantities to be purchased is equally as important as other elements. Without knowing types and quantities the program manager cannot accurately estimate costs or plan for production.

Timely Capture of Product Knowledge Needed to Support Future Business Decisions

In recent years, DOD has revised its weapons acquisition policy to support an evolutionary, knowledge-based strategy based on best practices—key to executing a future business case and making more informed business decisions.[18] With an evolutionary acquisition approach, new products are developed in increments based on available resources. Design elements that are not currently achievable are planned for and managed as separate acquisitions in future generations of the product with separate milestones, costs, and schedules. While JSF's acquisition strategy calls for initially delivering a small number of aircraft with limited capabilities, the program has committed to deliver the full capability by the end of system development and demonstration in 2013 within an established cost and schedule for a single increment, contrary to an evolutionary approach.

In addition, JSF's planned approach will not capture adequate knowledge about technologies, design, and manufacturing processes for investment decisions at key investment junctures. Our past work has shown that to ensure successful program outcomes, a high level of demonstrated knowledge must be attained at three key junctures for each increment in the program. Table 2 compares best practice and JSF knowledge expectations at each critical point.

[18]DOD Directive 5000.1, *The Defense Acquisition System* (May 2003); DOD Instruction 5000.2, *Operation of the Defense Acquisition System* (May 2003). The directive establishes evolutionary acquisition strategies as the preferred approach to satisfying DOD's operational needs. The directive also requires program managers to provide knowledge about key aspects of a system at key points in the acquisition process.

Table 2: Knowledge Attainment on JSF Program at Critical Junctures

Best practice	Knowledge point 1	Knowledge point 2	Knowledge point 3
	Should be achieved at development start.	Should be achieved by the design review.	Should be achieved by the start of production.
	Separate technology and product development, deliver mature technology, and have preliminary design based on systems engineering principles.	Completion of 90 percent of engineering drawing packages for structures and systems, critical design review completed, and design prototyped.	100 percent of critical manufacturing processes under statistical control, demonstration of a fully integrated product in its operational environment to show it will work as intended, and reliability goals demonstrated.
JSF practice	**Knowledge point 1 was not attained at milestone B in 2001.**	**Knowledge point 2 will not be attained by design review in 2006 under current plan.**	**Knowledge point 3 will not be attained by start of production in 2007 under current plan.**
	Failed to separate technology and product development. Critical technologies not mature and sound preliminary design not established. Several technologies not expected to be mature until after production begins.	The program estimates 35 percent of the engineering drawing packages are expected to be released at the critical design reviews. Also, prototype testing will not be done prior to the design review. The design will not be stable until after production begins.	Program does not expect to demonstrate that the critical processes are under statistical control until 2009. Program expects to demonstrate that a fully integrated aircraft will work as intended and meets reliability goals in 2010-2012 timeframe.

Source: GAO data and analysis of DOD data

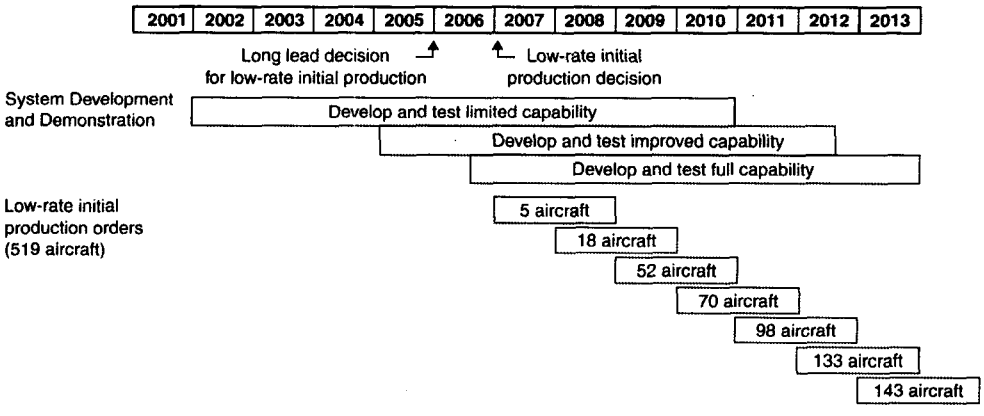
As shown in table 2, the JSF program will lack critical production knowledge when it plans to enter low-rate initial production in 2007. The department has included about $152.4 million in its fiscal year 2006 budget request to begin long lead funding for low-rate initial production. This production decision is critical, and the knowledge required to be captured by knowledge point 3 in our best practice model should be achieved before this critical juncture is reached. If production begins without knowledge that the design is mature, critical manufacturing processes are under control, and reliability is demonstrated, costly changes to the design and manufacturing processes can occur, driving up costs and delaying delivery of the needed capability to the warfighter. The size of the potential risk is illustrated in the production ramp-up and investments planned after this decision is made. Between 2007 (the start of low-rate production) and 2013 (the scheduled start of full-rate production) DOD plans to buy nearly 500 JSF aircraft—20 percent of its planned total buys—at a cost of roughly $50 billion. Under the program's preliminary plan, DOD expects to increase low-rate production from 5 aircraft a year to 143 aircraft a year, significantly increasing the financial investment after

production begins.[19] Between 2007 and 2009, the program plans to increase low-rate production spending from about $100 million a month to more than $500 million a month, and before development has ended and an integrated aircraft has undergone operational evaluations, DOD expects to spend nearly $1 billion a month.

To achieve its production rate, the program will invest significantly in tooling, facilities, and personnel. According to contractor officials, an additional $1.2 billion in tooling alone would be needed to ramp up the production rate to 143 aircraft a year. Over half of this increase would be needed by 2009—more than 2 years before operational flight testing begins. Figure 3 shows the planned production ramp up, along with the concurrently planned development program for the JSF.

[19]The preliminary plan was what was being considered at the time of our review. Since then, in its fiscal year 2006 budget submission, DOD has reduced the planned procurement quantities for the U.S. by 38 aircraft through fiscal year 2011. This includes planned quantities for the United Kingdom of 2 aircraft in fiscal year 2009, 4 aircraft in fiscal year 2010; 9 aircraft in fiscal year 2011, 9 aircraft in fiscal year 2012, and 10 aircraft in fiscal year 2013.

Figure 3: Overlap of JSF Low-Rate Production and System Development and Demonstration Activities (Includes U.S. and U.K. Quantities)



Source: GAO analysis of DOD data.

Following are examples of technology, design, and production knowledge that should be but will not be captured when the low-rate production decision is scheduled to be made.

- **Only one of JSF's eight critical technologies is expected to be demonstrated in an operational environment by the 2007 production decision.**

- Only about 40 percent of the 17 million lines of code needed for the system's software will have been released, and complex software needed to integrate the advanced mission systems is not scheduled for release until about 2010—3 years after JSF is scheduled to enter production. Further, most structural fatigue testing and radar cross section testing of full-up test articles are not planned to be completed until 2010.

- The program will not demonstrate that critical manufacturing processes are in statistical control, and flight testing of a fully configured and integrated JSF (with critical mission systems and prognostics technologies) is not scheduled until 2011.

Further, because of the risk created by the extreme overlap of development and production, the program office plans to place initial production orders on a cost reimbursement contract, placing a higher cost risk burden on the government than is normal. These contracts provide for payment of allowable incurred costs, to the extent prescribed in the contract. They are used when uncertainties involved in contract

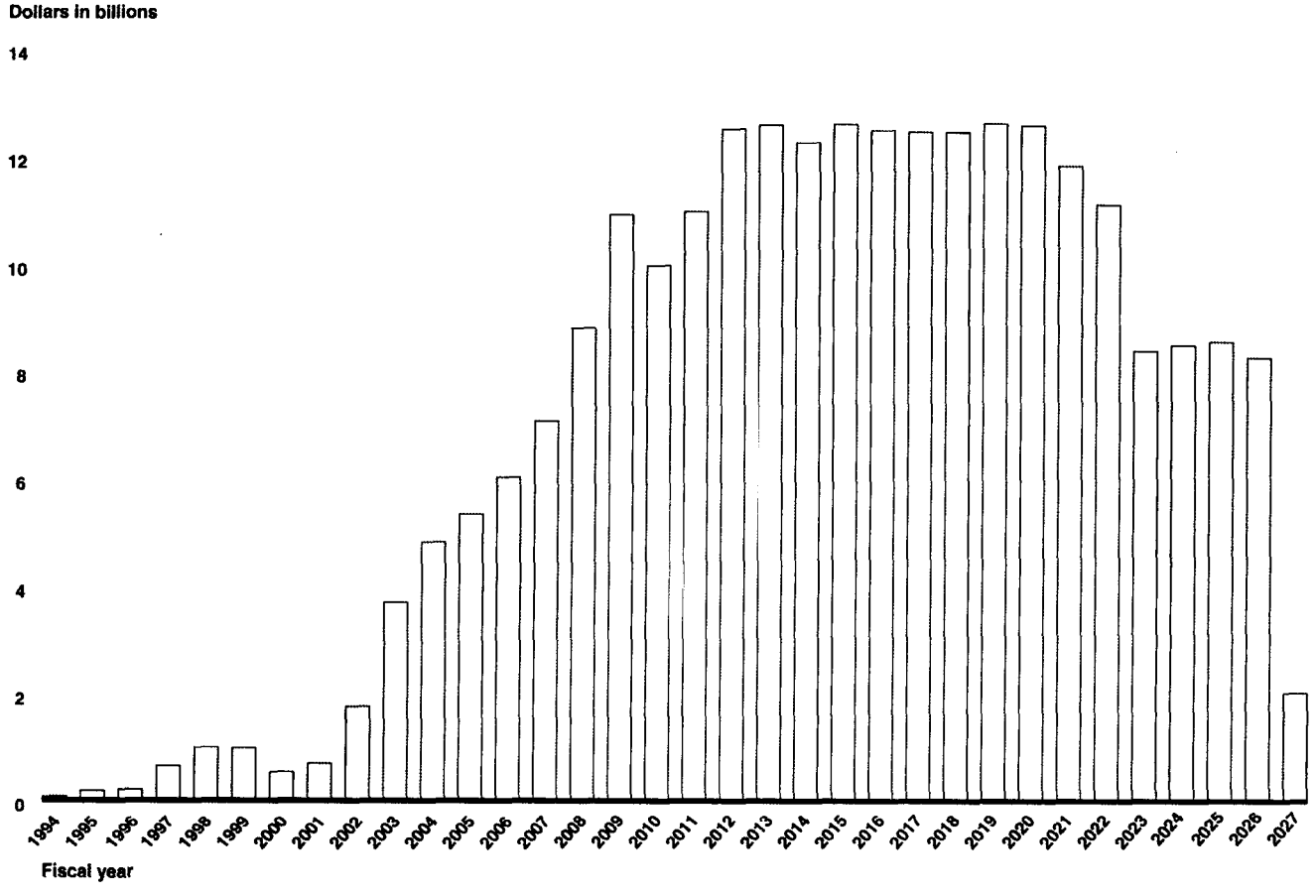
performance do not permit costs to be estimated with sufficient accuracy to use any type of fixed-price contract and place greater cost risk on the buyer—in this case, DOD. In the case of the JSF, a fixed-price contract will not be possible until late in the development program.

JSF's Substantial Funding Requirements May Be Difficult to Sustain in the Current Fiscal Environment

Regardless of likely increases in program costs, the sizable continued investment in JSF must be viewed within the context of the fiscal imbalance facing the nation over the next 10 years. The JSF program will have to compete with many other large defense programs as well as other priorities external to DOD's budget. JSF's acquisition strategy assumes an unprecedented $225 billion in funding over the next 22 years or an average of $10 billion a year (see fig. 4).[20]

[20]This is based on DOD's December 2003 JSF cost estimate.

Figure 4: JSF Program's Annual Funding Requirements (as of December 2003)



Source: GAO analysis of DOD data.

Funding challenges will be even greater if the program fails to stay within current cost and schedule estimates. For example, we estimate that another 1-year delay in JSF development would cost $4 billion to $5 billion based on current and expected development spending rates. A 10-percent increase in production costs would amount to $20 billion.

Implications for the Current Status of Tactical Aircraft Programs

Continuing changes and uncertainties in the F/A-22 and JSF programs present significant challenges to DOD in achieving its modernization plans which attempt to blend many factors within affordability constraints. Factors in the decision making process can include aircraft age, ownership costs, readiness, force structure, operating concepts, competing needs, available funds, defense policy, and others.[21] Today, both F/A-22 and JSF programs include significantly fewer aircraft than originally planned—30 percent fewer or over 1,000 aircraft. Deliveries intended to provide an operational capability have also been delayed in both programs, almost 10 years in the case of the F/A-22, requiring legacy systems to operate longer than planned. As legacy tactical aircraft age and near the end of their useful life, they require ever increasing investments to keep them ready and capable as the threat evolves—the cost of ownership.

The reduced F/A-22 force size, now fewer than 180 F/A-22 aircraft instead of 750 aircraft planned at the start of the program, could affect the Air Force's force structure and employment strategy. The Air Force still maintains it has a nominal requirement for 381 aircraft to meet its new Air and Space Expeditionary Forces—the operational mechanism through which the Air Force allocates forces to meet the combatant commanders' force rotation requirements—and Global Strike concept of operations. The Air Force planned on 10 F/A-22 squadrons to support this operational concept. Using the Air Force's normal methods for calculating force requirements, only about 110 aircraft of the total aircraft procured would be classified as available for combat and assignment to operational units[22]—yielding only 4 or 5 typical fighter squadrons for assigning across the planned 10 air and space expeditionary units. The reduced fleet size may require the Air Force to consider the F/A-22 as a low-density/high-demand asset, which would require changes in these expected management and employment strategies. It also has implications for related resources and plans, including military personnel requirements, numbers of operating locations, support equipment, spare parts, and logistical support mechanisms.

[21]GAO, *Tactical Aircraft: Modernization Plans Will Not Reduce Average Age of Aircraft*, GAO-01-163 (Washington, D.C.: Feb. 9, 2001). Today acquisition plans include 3,083 aircraft (F/A-22, FA-18EF, and JSF). The Air Force has been discussing buying fewer JSF, which would further lower the amount of planned new tactical aircraft.

[22]The remaining aircraft are used for training and development activities and to account for aircraft in for maintenance and those held in reserve for normal attrition.

Other factors will come to play in the 2005 Quadrennial Defense Review. OSD has directed the review to include an assessment of joint air dominance in future warfare and the contributions provided by all tactical aircraft. An announced defense policy goal is to redirect investment from areas of conventional warfare, where the United States enjoys a strong combat advantage, toward more transformational capabilities needed to counter "irregular" threats, such as the insurgency in Iraq and the ongoing war on terror. DOD is also conducting a set of joint capability reviews to ensure acquisition decisions are based on providing integrated capabilities rather than focused on individual weapons systems. The study results, although still months away, could further affect the future of the F/A-22 and JSF programs including the F/A-22's modernization plan. In these analyses, the new tactical aircraft will also have to compete for funding, priority, and mission assignments with operational systems, such as the F-15 and F/A-18, and other future systems, such as the Joint Unmanned Combat Air Systems.

The 2005 Quadrennial Defense Review provides an opportunity for DOD to assess tactical fixed-wing aircraft modernization plans and weigh options for accomplishing its specific as well as overarching tactical aircraft goals. It is critical that their investment be well-managed and balanced against DOD's other priorities. Through the review, DOD can seek answers to overall investment strategy questions:

- What is the role of tactical aircraft in relation to other defense capabilities?
- Will planned investments in tactical aircraft allow DOD to achieve these capabilities and overall transformational goals?
- Where disconnects exist between goals and expected investment outcomes, what are the impacts and how will DOD compensate to minimize future security and investment risks?

If DOD fails to answer these questions and continues with its current modernization strategy, it will likely arrive in the future with needs similar to those that exist today but with fewer options and resources to resolve those needs. As DOD evaluates its tactical aircraft investment alternatives, knowledge at the program level is needed to understand how the F/A-22 and JSF can help achieve overall tactical aircraft modernization goals. More specific questions need to be answered for these programs including:

- Is the F/A-22 the most cost-effective alternative to fill gaps in ground attack and intelligence-gathering requirements?

- How many F/A-22s are needed and affordable to carry out the aircraft's original mission, air superiority, and new ground attack and intelligence gathering missions?

- If requirements for the new F/A-22 capabilities are legitimate and not solvable by other means, does the Air Force have the resources (mature technologies, design knowledge, time, and money) to begin investments in a new development program for the F/A-22 enhancements?

- What is the immediate need for JSF aircraft? Delivery of its ultimate capability or replacing aging aircraft with an initial capability? Does the acquisition plan satisfy this need?

- Does the program have the required knowledge about needed quantities and capabilities and resources (mature technologies, design knowledge, time, and money) to develop a reliable business case at this time?

- Does DOD have the right acquisition strategy to develop and produce a JSF that will maximize its return on the more than $220 billion investment that remains in this program?

While the JSF program started off with a higher-risk approach by starting system development with immature technologies, now is the time to implement an evolutionary and knowledge-based acquisition strategy to manage the system development phase and stabilize the design before making large investments in tooling, labor, and facilities to test and manufacture the aircraft. The JSF is relatively early in its system development and demonstration phase and has an opportunity to learn from the F/A-22 program experience. It must take the time needed now to gather knowledge needed to resolve key issues that could ultimately result in additional cost increases, delays, and performance problems.

Our March 2005 reports on the F/A-22 and JSF made recommendations to the Secretary of Defense that would require answering some of these questions before making significant additional investments. For the F/A-22, we recommended that a new business case be made to justify investments in new capabilities and the quantities needed to satisfy mission requirements. For the JSF, we recommended the establishment of an executable program consistent with policy and best practices, including an affordable first increment with its own business case, and the implementation of a knowledge-based acquisition approach to guide future investments and reduce risks.

Mr. Chairman, this concludes my prepared statement. I would be happy to respond to any questions that you or other members of the Subcommittee may have.

Contacts and Staff Acknowledgments

For future questions about our work on the F/A-22 or JSF, please call me or Michael J. Hazard at (202) 512-4841. Other individuals making key contributions to this statement include Michael W. Aiken, Marvin E. Bonner, Lily J. Chin, Matthew T. Drerup, Bruce D. Fairbairn, Steven M. Hunter, Matthew B. Lea, David R. Schilling, and Adam Vodraska.

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UPDATED: June 16, 2005

Full Version

The F-35, ready for prime time?

BY: ADAM J. HEBERT, AIR FORCE MAGAZINE
06/02/2005

The past year has been a turbulent one for the huge Joint Strike Fighter project. Manufacturers began assembling the first flying F-35, making the transition from abstract design to well-defined aircraft. Then, however, program officials concluded that they needed to slow things down. Weight problems had cropped up. The design was seen to be immature.

A year ago, JSF officials were just beginning to come to terms with program shortcomings. (See "The F-35 Gets Real," March 2004, p. 44.) It was during preparations for the critical design review (CDR) that "we really saw the performance [problems] ... manifesting themselves," said Rear Adm. Steven L. Enewold, JSF program director.

Indeed, Enewold and others concluded the aircraft was not ready for CDR.

An end of 2004 assessment by the contractor, Lockheed Martin, noted that the F-35 program is "the most complex fighter program ever undertaken." As a result, it warned, "serious" problems can erupt "with remarkably short notice."

The F-35 was overweight, with the worst offender being the short takeoff and vertical landing (STOVL) variant. It had surpassed its limit by a whopping 3,000 pounds.

Recognizing that complex fixes were required, the program office slammed on the brakes. Major events—critical design review, first flight, initial operational capability—all were delayed by one to two years.

Ruthless Weight Cuts

The contractors and program office assembled a weight reduction team and attacked the problem from several directions. Roughly 2,700 pounds was cut from the STOVL aircraft, and the "equivalent" of 600 additional pounds was eliminated by improving the propulsion system and increasing thrust. The STOVL weight savings trickled down to the other variants.

The end result, according to program officials, is that the three F-35 variants are again projected to meet all key performance parameters. Critical warfighting capabilities are still being met, and a realistic schedule is in place.

The Air Force will buy both the F-35A conventional takeoff and landing (CTOL)

variant to replace its huge fleet of F-16s and the F-35B STOVL jump jet as a follow-on to the A-10 attack aircraft.

The Marine Corps is buying the F-35B to replace its fleet of old F/A-18 Hornets and AV-8 Harriers. The Navy will use the carrier-capable F-35C as the replacement for its older F/A-18.

Enewold said he is cautiously optimistic that the F-35 will arrive on time to meet DOD's urgent need for new combat aircraft.

"We laid out a schedule for ourselves last June," Enewold noted in an interview with Air Force Magazine. Since the program was restructured, F-35 development has stayed on schedule.

It had better. Three US armed services—not to mention foreign customers—are depending on the arrival of this airplane, and there is no more flexibility to accommodate delays.

Projected IOC for Marine Corps aircraft is 2012. For USAF and Navy fighters, the IOC year is 2013. These new dates mark a two-year postponement for the Marine Corps and Air Force and one year for the Navy. Enewold said his program office considers the new dates inviolable.

For the Marine Corps, timing is critical. The service long ago passed up the opportunity to acquire the new F/A-18E/F Super Hornet fighter and chose to wait for the more advanced JSF. It can't afford a holdup. According to Enewold, the Corps wants to avoid having to pay for major structural rework to its F/A-18s or postpone planned retirement of its old Harriers.

The Air Force has not yet decided how many of each JSF type it will order. The service has "made no commitment" about how many of its 1,763 F-35s will be STOVL and how many conventional, said Enewold. As for the possible STOVL procurement, he said, "I've heard anything from 100 to ... 500."

To the Air Force, even the total quantity is in play. Gen. John P. Jumper, the Air Force Chief of Staff, said, "I think that we will see an overall decrease" in the planned procurement of F-35s. Because of JSF's greater capabilities and expected reliability, he pointed out, it is probably not necessary to trade F-16s and A-10s on a "one-for-one" basis.

"Clearly the JSF will be vastly superior to the aircraft it replaces," noted Maj. Gen. Donald J. Hoffman, Air Combat Command requirements director. ACC is currently evaluating the number of STOVL and CTOL F-35s needed for future operational requirements.

The most specific public estimate of Air Force needs came from the Government Accountability Office. In a March report, GAO wrote that ACC officials told them last December, "The Air Force is considering buying about 250 [STOVL] JSFs and about 1,300 [CTOL] JSFs. This would reduce the total number of [F-35s] to be acquired by 213."

USAF Rebuffed

An Air Force move to trim F-35 purchases was rebuffed by senior Pentagon leaders last December. In the Fiscal 2006 budget drills, DOD left the JSF budget untouched even as it slashed funding for F/A-22 and C-130J aircraft.

Getting the F-35 is important for the Air Force but, as the IOC dates show, slightly less urgent than it is for the Marine Corps. All things considered, officials say that USAF's legacy strike fighters are still in decent shape, buying the Air Force some time while the F-35 develops.

A-10s have been heavily tasked in Afghanistan and Iraq for more than two years. Thanks to attentive maintenance, and "with serious input from [the] users," the health of the 22-year-old Warthog is good, said Maj. Gen. Elizabeth Ann Harrell, ACC director of maintenance and logistics.

F-16s have "different challenges," Harrell noted. They fly more stressful profiles. ACC could "beef up the airframe," she explained, but no one can calculate the long-term prospects for KC-135-type corrosion or similar problems.

USAF recently decided to upgrade every one of its 356 Warthogs to an A-10C configuration. This adds precision weapons capability, updated cockpits, and, in conjunction with A-10 structural upgrades, allows the service to buy STOVL F-35s later in the production run than it first thought would be required. The Air Force has structural and performance improvements planned for the F-16 as well.

Thus, the Air Force still has several years to sort out exactly how many F-35Bs it wants. Air Force-specific changes to the F-35 are considered "post-system design and development" changes, which will be made later in the program. This activity will lead to a STOVL in-service date of approximately 2014, a program official said.

The F-35 is expected to be vastly superior to both of the aircraft that it is replacing. Hoffman noted that this creates a delicate balancing act in planning future inventories.

On official charts of the Air Force fighter force, lines corresponding to yearly aircraft inventories make a steep decline for several years, bottom out and stay low for a while, and then turn back upward. This graphical depiction—a line high at either end, with a major depression in between—is referred to as the "fighter bathtub," in that it resembles the curve of a bathtub. The Air Force is "trying to minimize the bathtub"—meaning, the shortage of fighters the service will suffer later this decade as F-16s begin to age out and before the F-35 is ready to replace them in bulk. With 10 rotating Air and Space Expeditionary Forces to equip, small fleets don't "divide well," said Hoffman.

The Needs of Foreign Partners

One of the F-35's unique aspects is the massive amount of foreign participation

One of the F-35's unique aspects is the massive amount of foreign participation in the program. The United Kingdom has a special role in the fighter's development and has committed to buying 150 short takeoff and vertical landing variants for the Royal Air Force and Navy. Other international partners include Australia, Canada, Denmark, Italy, the Netherlands, Norway, and Turkey, and they are contributing various levels of manpower, money, and expertise to the program. In 2004, Singapore and Israel joined the program as "security cooperation participants."

Rear Adm. Steven L. Enewold, Joint Strike Fighter program director, observed that recent program delays leave very little room for error for a couple of partner nations.

The British and Australians "are very dependent upon our success because they've already started planning ... the actual retirement of some of their systems," he said. "They're counting desperately on us to fill their force structure," so that geriatric British Harriers and Australian F-111s can be retired as planned.

The British are "in more critical shape than we are, frankly," said Enewold. That nation has already committed to drawing down its Harrier force and retiring three aircraft carriers. Two new British carriers—designed with the F-35 in mind—are being built, but now the first of those will likely be completed before its aircraft are ready.

Australia, meanwhile, will start phasing out its F-111s around 2012. That nation is also looking for new fighters at the very beginning of the JSF production run.

This spring, the program began formal negotiations with the international partners to create international production and sustainment plans. "When you get into sustainment, every one of the international countries [has] aspirations of doing things in their own country," Enewold noted. The program office will determine "what we think is the most economical, cost-effective plan."

For example, three major F-35 repair facilities might be desirable—one each in the US, Europe, and the Pacific. This would ensure that F-35s do not have to return to the United States for engine overhauls and other maintenance that can be performed in-theater.

"Every country thinks that their country's the right place to do that," Enewold said. There is already a term for the nationalistic outcome that is the likely result: "pay to be different."

If national aspirations get in the way of overall program efficiency, "we'll have that discussion" later, Enewold said. The plan is to have a signed memorandum of understanding about international participation ready by the end of 2006.

No "Capabilities Gap"?

Yet, people rarely talk about a fighter "capabilities gap," because there probably isn't one, Hoffman said. If analysts were to count the number of precision

weapons USAF's fighter fleet can deliver rather than the number of fighter "tails" on the ramps, the tally would not show the same sort of bathtub, he noted.

Enewold said it is no accident the F-35 earned DOD's support once again late last year. The program had just shown the ability to work through its weight and design problems. Heading into the planned design review in the spring of 2004, the program was "very technically unstable," Enewold said.

Since that time, progress has been made in overall design, engine testing, and assembly of flying aircraft. There are a "whole lot of things that seem to be coalescing now," Enewold said. Without progress over the past year, "we would not have done very well" in the recent budget deliberations, he said.

The F-35 program has been helped politically by its sheer scope and magnitude. It is the largest acquisition program the Pentagon has ever known, with huge numbers of industrial connections. JSF will be a family of highly versatile aircraft. "We're going to be darn good" at almost every fighter mission, Enewold said, "and the best overall."

Because several different programs would be needed to replace JSF, the massive program is actually "probably the most cost-effective" way to meet a wide range of future warfighting needs, he said.

For the US Air Force, US Marine Corps, Royal Air Force, Royal Navy, and others that may buy the STOVL version of the F-35, there may be no realistic alternative.

The Air Force recently discovered that its A-10s were the only fighters that could operate from many of the short and rough airfields in and around Afghanistan, said USAF Brig. Gen. (sel.) Charles R. Davis, JSF deputy director. That helped drive the requirement for the F-35 STOVL to replace the A-10.

"When you start talking about expeditionary ops, especially forward deployed people, I don't see any alternative to the STOVL version," said Enewold. Nothing else in development will "get up close to the battlefield" like a short takeoff fighter.

Plans call for equipping the Marine Corps, RAF, and Royal Navy with essentially the same type of STOVL F-35, but the Air Force has unique needs. For example, the service does not need to take off within 550 feet, from the deck of a warship, as is the case with the Marine Corps. For the Air Force, a short takeoff distance is 3,000 feet. The difference provides the flexibility to add additional fuel or weapons for combat.

And Air Force discussions with the Army have produced some specific F-35 preferences. Col. Dave Watt, director of ACC's JSF management office, has noted there is great interest in smaller weapons and longer loiter time.

With STOVL, the Air Force will be able to offer those capabilities even from short runways. The Marine Corps already emphasized close air support (CAS) capabilities while designing the aircraft, he said, and that pays benefits for the Air Force F-35B

Force F-35B.

The A-10 has a "very specific mission," Watt noted, and the F-16 is typically highly "missionized" to perform a specific job such as ground attack or suppression of enemy air defenses. The F-35, whether CTOL or STOVL, "will be able to do a lot more" than either of those aircraft, he said.

Gas and Gun Issues

USAF was originally interested in equipping its F-35s with a boom-style refueling receptacle, the kind of system used by all other Air Force fighters. However, Navy and Marine Corps fighters use a probe-and-drogue (basket-style) refueling system, and the F-35B is designed in this configuration.

Meanwhile, ACC officials have sought an internal gun for the aircraft, instead of the removable, less-stealthy, missionized gun specified by the Marine Corps.

"In a highly complex, dense urban environment" such as that in Iraq, the Air Force finds itself using fighter guns quite a bit, Davis said. Strafing is valuable because it is precise and causes limited collateral damage. An internal weapon maintains the airframe's stealthy characteristics and reduces drag.

Davis said the program office informed the Air Force that STOVL F-35s could be modified to add either the boom receptacle or an internal gun, but there is not room in the airframe for both. The Air Force has chosen to go with the gun of its choice.

The cornerstone of the JSF program is low cost. Program officials acknowledge that the F-35 program faces "unprecedented affordability challenges," and the bar has been set high. At present, the Pentagon estimates the unit cost of the vanilla Air Force variant to be $45 million, with the Navy and STOVL variants to be $60 million (as calculated in 2002 dollars).

As befits the F-35's joint and cost-conscious nature, plans call for consolidated training. Specifics have yet to be worked out, but it is possible that all pilot and maintenance training could occur at a single location.

"We're waiting to see what the BRAC [base realignment and closure] commission has to say," Enewold said. Most participants "want to have some joint and combined training," and the BRAC commission has been tasked with recommending the initial training location. Enewold added, "Then we can make a better assessment of the most cost-effective way to get the training system put in the field."

With the weight problem evidently resolved, software development is now deemed the biggest risk area as the program office works its way toward next year's first flight and critical design review. The F-35 will use lots of commercial-off-the-shelf software packages, Enewold said. Getting the software assembled, integrated, tested, and certified "just takes time," he said.

The first flying fighter, dubbed A-1, is being assembled with what Enewold called

"representative tooling," but it does not have "a representative airframe." A-1 is based on an older design and does not incorporate the weight-saving engineering changes. A-1 will fly with a production-representative engine. First flight is scheduled for late 2006.

The STOVL Diet

The Joint Strike Fighter program office and prime contractor Lockheed Martin had to slash roughly 3,000 pounds from the short takeoff and vertical landing (STOVL) F-35 last year to meet performance requirements. The changes also benefited the conventional and carrier F-35 variants, as they, too, had gotten fat.

Some of the major changes included propulsion system improvements for more thrust, a new assembly joint that weighs 160 pounds less, and a series of electrical system changes netting 222 pounds of weight savings.

Perhaps most significantly, the weapons bay was redesigned. The F-35B STOVL weapons bay has a "long and sordid story," said Rear Adm. Steven L. Enewold, program director. The operational requirements document dictates that the carrier and conventional takeoff and landing variants have internal bays large enough for two 2,000-pound weapons; STOVL would only have to carry a pair of 1,000 pounders.

"About a year into the program, we said it would really improve our commonality and reduce our flight testing ... if we could get that same weapon bay into STOVL," said Enewold. So it was made to fit. But "when we got into the weight discussion," officials determined the larger weapons bay had to go, so the 1,000-pound bay is back.

Opening up that internal space "allowed us to do a great many things," Enewold said, and was "the linchpin of getting the STOVL design weight down." The aircraft can still carry 2,000-pound weapons on wing hardpoints, and there is even an external 5,000-pound station. In an era of increasing concern about collateral damage, smaller weapons are in vogue, and this was deemed an acceptable trade. "It made STOVL viable around the ship," Enewold said.

There are still about 300 pounds of additional weight-saving "ideas" the program office is looking into. They may not be worth implementing.

"We're struggling a little bit," Enewold said, because if it costs the government $50 million to cut 300 pounds, "I'm just not sure if that's a great trade or not. The operational guys would say, 'Great trade.' The money people may not."

Brig Gen. (sel.) Charles R. Davis, JSF deputy director, added that the remaining possible weight savings make for tough decisions. "Lots of items weigh five, seven, [or] 12 pounds," he said—all the big cuts have been made.

Under the Skin

One would notice few external differences between A-1 and the current-design aircraft, Enewold noted, because "almost all the changes are inside the skin."

Enewold said that Lockheed Martin's Fort Worth, Tex., assembly plant may benefit from help when full-rate production begins. "When we start getting into production rates of 20 a month or so, it's not clear to us that that kind of rate is most efficiently done at a single site," Enewold said. The program may need two assembly sites for efficiency or surge capacity to meet foreign purchase requirements.

It is not a given that future expansion will stay in the United States: Major F-35 subsections are already being produced in Britain by BAE Systems. Northrop Grumman executive Steve Briggs told the London Sunday Times last year that, "at the peak, we're talking about making one new JSF every day. That's a monster to feed." Briggs added that he doubted there are "enough high-tech milling machines in the entire US to keep pace with making the components for this production line."

To effectively meet immediate combat requirements with minimum risk, the F-35 will be fielded through a spiral, "block" approach. The first operational aircraft, Block 1, will have modest capabilities. It will be followed in rapid succession by two more-powerful blocks.

For the initial warfighting capability, "you need to have a radar, you need to have missile warning," an electronic warfare system, and be able to drop bombs and shoot missiles, said Enewold. Block 1 will offer stealth, air-to-air missiles, a data link, and Joint Direct Attack Munitions, he said, describing it as "pretty rudimentary warfighting."

Block 2 will add "some close air support," counterair, and interdiction missions, as well as an expanded weapons portfolio. The program office is trying to define exactly which Block 2 weapons "have the biggest bang for the warfighter," Enewold said. The specifics should be locked in this October, with Block 2 operational testing complete in 2012.

Block 3 will be the full-up F-35 with solid capabilities across the entire mission spectrum, including offensive and defensive air superiority missions, suppression and destruction of enemy air defenses, and CAS. This is "the whole gamut of strike warfare," Enewold said. Plans call for Block 3 capabilities to be frozen in 2006 with testing completed in 2013.

The program also continues to refine the mission profiles. Weight is not a key performance parameter, but range is (measured as combat radius). The STOVL is required to have a combat radius of 518 miles, the CTOL variant 678 miles, and the carrier version 690 miles. All three variants are expected to meet these standards, but the program office would like to eliminate any uncertainty.