

CRS Report for Congress

F-35 Lightning II Joint Strike Fighter (JSF) Program: Background, Status, and Issues

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Summary

The Defense Department's F-35 Lightning II Joint Strike Fighter (JSF) is one of three aircraft modernization programs in tactical aviation, the others being the Air Force F-22A fighter and the Navy F/A-18E/F fighter/attack plane. In November 1996, the Defense Department selected two major aerospace companies, Boeing and Lockheed Martin, to demonstrate competing designs for the JSF, a joint-service and multi-role fighter/attack plane. Lockheed Martin won this competition and was selected to develop and produce the JSF, a family of aircraft including conventional take-off and landing (CTOL), carrier-capable (CV), and short take-off vertical landing (STOVL) versions for the U.S. Air Force, Navy, and Marine Corps, the United Kingdom, as well as other allied services. Originally designated the Joint Advanced Strike Technology (JAST) program, the JSF program has attracted considerable attention in Congress because of concerns about its cost, effects on the defense industrial base, and implications for U.S. national security in the 21st century.

The JAST/JSF program evolved in response to the high cost of tactical aviation, the need to deploy fewer types of aircraft to reduce acquisition and operating costs, and projections of future threat scenarios and enemy capabilities. The program's rationale and primary emphasis is joint-service development of a next-generation multi-role strike aircraft that can be produced in affordable variants to meet different operational requirements. Developing an affordable tri-service family of CTOL (Air Force and Navy variants) and STOVL aircraft with different (but similar) combat missions poses major technological challenges. If the JSF is to have joint-service support, the program must yield affordable aircraft that can meet such divergent needs as those of the U.S. Air Force for a successor to its low-cost F-16 and A-10 fighter/attack planes, those of the U.S. Marine Corps and the UK Royal Air Force and Navy for a successor to their Harrier STOVL aircraft, and the U.S. Navy's need for a successor to older F/A-18s and a complement to its F/A-18E/F fighter/attack planes.

This report discusses the background, status, and current issues of the JSF program. Additional information and analysis can be found in CRS Report RL33543, *Tactical Aircraft Modernization: Issues for Congress*, which also discusses the Air Force F-22A, the Navy F/A-18EF, and the Marine Corps V-22. The JSF program is also addressed in CRS Report RL33390, *Proposed Termination of Joint Strike Fighter (JSF) F136 Alternate Engine*; CRS Report RS21488, *Navy-Marine Corps Tactical Air Integration Plan: Background and Issues for Congress*; and CRS Report RL31360, *Joint Strike Fighter (JSF): Potential National Security Questions Pertaining to a Single Production Line*.

This report will be updated as events warrant.

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Introduction

The Joint Strike Fighter (JSF) program is developing and building a family of next-generation tactical aircraft for the Air Force, the Marine Corps, and the Navy, as well as for export. In addition, unlike the F-22A, the F-35 was designed for export from the onset and will be the first U.S. export of a stealth aircraft. As now projected, the JSF is the Defense Department's (DOD's) largest acquisition program in terms of cost and number of aircraft to be produced and the longest in terms of procurement duration. Current DOD plans call for production of 2,458 aircraft in three versions over a 28-year delivery period.¹ An additional 738 aircraft are expected to be ordered by the JSF development partner nations of the UK, Australia, Italy, Canada, Denmark, Turkey, the Netherlands, and Norway.²

The U.S. Marine Corps and the United Kingdom's Royal Air Force and Navy plan to procure a short take-off vertical landing (STOVL) version of the plane to replace their current fleets of Harrier vertical/short take-off and landing (VSTOL) attack planes.³ The U.S. Navy plans to procure a carrier-capable version — termed a CV — to replace older carrier-based aircraft. Currently, the Department of the Navy's acquisition plans call for a total of 680 JSFs, with the determination still pending on the split between the Marine STOVLs and Navy's carrier CVs. The United Kingdom anticipates a purchase of 138 STOVL JSFs for its Navy and Air Force.

The U.S. Air Force's program of record is to purchase 1,763 conventional takeoff and landing (CTOL) versions of the F-35 to replace its current force of F-16s and A-10s. In February 2003, Air Force officials announced its intentions to analyze acquisition of the STOVL JSF to improve future close air support (CAS)

¹ Fifteen of these aircraft will be purchased with RDT&E funds and will be used for developmental testing.

² Current anticipated partner orders: UK: 138; Italy: 131; Australia: 100; Turkey: 100; Canada: 88; Netherlands: 85; Denmark: 48; Norway: 48. Michael Sirak, "F-35 Nations on Track to Sign New MOU, Says JSF Program Office," *Defense Daily*, November 20, 2006.

³ The U.S. Marine Corps and the UK Royal Navy and Royal Air Force operate versions of the AV-8A/B Harrier aircraft flown by these services since the early 1970s. CRS Report 81-180, *The British Harrier V/STOL Aircraft: Analysis of Operational Experience and Relevance to U.S. Tactical Aviation* (out of print; available from the author at 7-2577).

capabilities.⁴ To date, however, the Air Force has not committed to purchasing other variants besides its CTOL platform. While speculation continues as to the procurement intentions of the USAF (the largest purchaser of the F-35), the Air Force official position still remains at 1,763 CTOL F-35s.⁵

Figure 1. F-35 *Lightning II* Joint Strike Fighter



Background

The JSF program emerged in late 1995 from the Joint Advanced Strike Technology (JAST) program, which began in late 1993 as a result of the Administration's Bottom-Up Review (BUR) of U.S. defense policy and programs. Having affirmed plans to abandon development of both the A-12/AFX aircraft that was to replace the Navy's A-6 attack planes and the multi-role fighter (MRF) that the Air Force had considered to replace its F-16s, the BUR envisaged the JAST program as a replacement for both these programs. In 1995, in response to congressional direction, a program led by the Defense Advanced Research Projects Agency (DARPA) to develop an advanced short takeoff and vertical landing (ASTOVL)

⁴ Lorenzo Cortes, "Air Force to Study Acquisition of F-35-B STOVL JSF," *Defense Daily*, February 13, 2004; Gail Kaufman, "U.S. Air Force Wants STOVL JSFs," *Defense News*, February 12, 2004; and Christopher Castelli, "Overall Impact of Air Force Interest in F-35 STOVL Variant is Unclear," *Inside the Navy*, March 1, 2004.

⁵ Marc Selinger, "Jumper Confirms Air Force Plans to Cut Joint Strike Fighter Purchase," *Aerospace Daily & Defense Report*, December 15, 2004.

aircraft was incorporated into the JAST program. This opened the way for Marine Corps and British Navy participation.⁶ The name of the program was then changed to Joint Strike Fighter to focus on joint development and production of a next-generation fighter/attack plane. And unlike the so-called “joint” Air Force/Navy TFX program of the 1960s, program proponents note the JAST/JSF program has been truly “joint” from its inception.

During the JAST/JSF program’s 1994-1996 concept development phase, three different aircraft designs were proposed by Boeing, Lockheed Martin, and McDonnell Douglas (the latter teamed with Northrop Grumman and British Aerospace) in a competitive program expected to shape the future of U.S. tactical aviation and the U.S. defense industrial base.⁷ On November 16, 1996, the Defense Department announced that Boeing and Lockheed Martin had been chosen to compete in the 1997-2001 concept demonstration phase, in which each contractor would build and flight-test two aircraft to demonstrate their concepts for three JSF variants (conventional takeoff/landing, short-field takeoff/vertical landing, and the carrier takeoff/landing). On October 26, 2001, DOD selected a team of contractors led by Lockheed Martin to develop and produce the JSF. The three variants — CTOL, CV and STOVL aircraft — are to have maximum commonality in airframe, engine, and avionics components to reduce development, production, and operation and support costs.

Mainly because of their projected costs, three tactical aircraft programs are being analyzed by both Congress and the Administration to determine the best combination of the types and numbers of aircraft to meet U.S. armed forces may need in the future — the emergent JSF program, the Air Force F-22A program, and the Navy’s F/A-18E/F program. Congressional decisions on these programs will have important implications for defense funding requirements, U.S. military capabilities, and the U.S. aerospace industry.

Design and Performance

Contrary to some misconceptions that the Joint Strike Fighter would be one aircraft used by several services for different missions, the program focused on the development and production of three variants with common components: a land-based conventional take-off and landing (CTOL) version for the Air Force, a carrier-based version (CV) for the Navy, and a short take-off vertical landing (STOVL) version for the Marines and the UK. The JSF program is a family of aircraft performing similar missions, with a mix of components, systems, and technologies.

⁶ Since the early 1990s, DARPA had funded various STOVL projects expected to develop aircraft to replace both U.S. Marine Corps AV-8B Harriers and the UK Royal Navy’s Sea Harriers. The merger of these research-development efforts with the JAST program in early 1995 cleared the way for U.S.-UK collaboration in JSF development.

⁷ John Tirpak, “Strike Fighter,” *Air Force Magazine*, October 1996, pp. 22-28; Philip Hough, “An Aircraft for the 21st Century,” *Sea Power*, November 1996, pp. 33-34.

Component commonality is projected to be at 70% to 90%.⁸ Many of the high-cost components are common, including engines, avionics, and major structural components of the airframe. Former Secretary of Defense William Cohen stated that the JSF's joint approach "avoids the three parallel development programs for service-unique aircraft that would have otherwise been necessary, saving at least \$15 billion."⁹

The JSF will be powered by the Pratt & Whitney F135 engine, which was derived from the F-22A's Pratt & Whitney F119 power plant. Consistent with congressional direction in 1996, DOD established an alternative engine program (F136), with the General Electric/Rolls-Royce Fighter Engine Team, to compete with the F135 for JSF production and operations and support (O&S) contracts. In addition to teaming up with GE on the F136 engine, Rolls-Royce is contracted to develop and produce the STOVL lift fan system that will be used with both the F135 and F136 engines. The net cost-benefit of an alternate engine for the JSF program has periodically been debated, and DOD has twice attempted to eliminate funding for the F136 (removing funding for the engine in the FY2007 and FY2008 budget requests).¹⁰ Congress has acted multiple times throughout the program's history to ensure continued DOD support for the F136.

All JSF planes will be fifth-generation, single-engine, single-seat aircraft with supersonic dash capability and some degree of stealth (low observability to radar and other sensors).¹¹ Combat ranges and payloads will vary in the different service variants. For example, as currently planned, combat radius requirements are 590-690 nautical miles (nm) for the Air Force, 600-730 nm for the Navy, and 450-550 nm for the Marine Corps. All three variants are planned to carry weapons internally (two 2,000 lb. weapons for the CTOL and CV variant and two 1,000 lb. weapons for the STOVL).¹² All versions will also carry AIM-120 AMRAAMs (advanced medium-

⁸ Operational Requirements call for 70% to 90% commonality between all variants. Lockheed Martin notes currently that over 80% of all parts are common on all three variants. Clarence A. Robinson, Jr., "A New Fighter Paradigm," *F-35 Lightning II Commemorating First Flight*.

⁹ Letter from Secretary of Defense William S. Cohen to Rep. Jerry Lewis, June 22, 2000. Transcript made available by *Inside the Airforce*, June 23, 2000.

¹⁰ See CRS Report RL33390, *Proposed Termination of Joint Strike Fighter (JSF) F136 Alternate Engine*, for more information. Also see "Dual Engine Development Could Saddle JSF with up to \$800 Million Bill," *Inside the Navy*, August 5, 1996, p. 2; "Despite Demand for Second JSF Engine Source, F120 Comes up Short," *Aerospace Daily*, October 18, 1996, p. 102; U.S. Congressional Budget Office, *A Look at Tomorrow's Tactical Air Forces* by Lane Pierrot and Jo Ann Vines, January 1997, p. 53.

¹¹ Fifth-generation fighters combine new developments such as thrust vectoring, composite materials, supercruise, stealth technology, advanced radar and sensors, and integrated avionics to greatly improve pilot situational awareness. Currently, only the F-22 and F-35 are considered fifth-generation. Russia has a fifth-generation fighter under development and it is due for its first flight in 2009.

¹² The STOVL variant weapons load was reduced to assist with overall aircraft weight reduction efforts in 2004. Background information provided by the F-35 Joint Program (continued...)

range air-to-air missiles, with a range of about 26 nm/48 km depending on altitude¹³). General Dynamics is under contract to develop the 25mm gun for the F-35. The four-barrel GD-425 under development for the F-35 will be carried internally in the CTOL version and externally in the CV and STOVL variants.¹⁴

Performance features regarding radar signature, speed, range, and payload were determined on the basis of trade-offs between performance and cost, with the latter being a critical factor. Program officials have emphasized that cost and performance trade-offs are critical elements of the program, and were the basis for the joint-service operational requirements that determined the selection of the Lockheed Martin contractor team for the System Development and Demonstration (SDD) phase.¹⁵ The 1997 Quadrennial Defence Review (QDR) report observed that “Uncertainties in prospective JSF production cost warrant careful Departmental oversight of the cost-benefit tradeoffs in design to ensure that modernization and force structure remain in balance over the long term.”¹⁶ In other words, production costs must be low enough that these aircraft can be bought in sufficient quantities to maintain desired force levels. Thus, the parameters of the JSF’s performance and operational capabilities are subject to refinement for reasons of cost, technological developments, and future threat assessments.¹⁷

In response to the Department of the Navy’s need to replace its aging EA-6B Prowler electronic attack aircraft, Lockheed Martin has proposed the development of a two-seat electronic attack variant of the JSF. Dubbed the EA-35B, the aircraft could potentially be available by 2015, according to industry representatives. A baseline F-35 will already have a limited electronic attack capability with its Active Electronically Scanned Array radar (AESA). The Navy currently plans to replace the Prowler with an electronic attack version of the F/A-18E/F. The Marine Corps, which currently has no plans to procure either F/A-18E/Fs or the EA-18G electronic attack variant, has studied the pros and cons of a dedicated EA-35 aircraft, but reportedly will opt instead to improve the electronic attack capabilities of its baseline F-35 fighters.¹⁸ Currently, there are no formal proposals or funding for an electronic

¹² (...continued)

Office, September 2007.

¹³ Steven Zaloga, “AIM-120 AMRAAM,” *World Missiles Briefing*, Teal Group Corp., January 1997, p. 5.

¹⁴ “JSF programs says gun system is ahead of schedule, under cost,” *Aerospace Daily and Defense Report*, September 26, 2005.

¹⁵ “Tradeoffs Will Be Made to Contain JSF Costs,” *Aerospace Daily*, September 26, 1997, p. 469.

¹⁶ U.S. Department of Defense, *Report of the Quadrennial Defense Review* [by] William S. Cohen, Secretary of Defense, May 1997, p. 46.

¹⁷ The Joint Program Office notes that the F-35’s Key Performance Parameters (KPPs) have not changed since Milestone B in 2001.

¹⁸ Craig Hoyle, “US Outlines New Electronic Attack Aircraft,” *Jane’s Defence Weekly*, June 4, 2003. Graham Warwick, “JSF Team Rejects Dedicated EA-35,” *Flight International*, (continued...)

attack variant of the F-35. However, the idea of an electronic attack variant could gain momentum in the future after the Air Force lost support for its B-52 Stand-Off Jammer proposal.¹⁹

Program Management

The JSF program is jointly staffed and managed by the Department of the Air Force and the Department of the Navy (comprising the Navy and the Marine Corps), with coordination among the services reinforced by alternating Air Force and Navy Department officials in key management positions. For example, Lt. General George Muellner, USAF, was the program's first director in 1994, with Rear Admiral Craig Steidle, USN, serving as deputy director. Subsequently, Rear Admiral Steidle directed the program, with Brigadier General Leslie Kenne, USAF, as his deputy in late 1996 and his successor as program director in August 1997. The current director is Maj. Gen. Charles Davis, USAF. Service Acquisition Executive (SAE) responsibility also alternates, with the Air Force having that responsibility when the program director is from the Navy Department, and the Navy in that role with an Air Force director of the program.

In 2004, appropriations conferees followed a House recommendation to direct DOD to review this alternative management arrangement. House appropriators believed that "management of program acquisition should remain with one Service, and that the U.S. Navy, due to its significant investment in two variants of the F-35 should be assigned all acquisition executive oversight responsibilities."²⁰ Conferees directed that DOD submit a report on the potential efficacy of this change. Prior to the release of the DOD report, former Air Force Chief of Staff General Jumper was quoted as saying that he also supported putting one service in charge of JSF program acquisition.²¹ However, General Jumper highlighted the significant investment the Air Force was making in the JSF program in response to the congressional language favoring the Navy. In DOD's response to Congress, the report noted the current arrangement ensures one Service does not have a "disproportionate voice" when it comes to program decisions and that the current system is "responsive, efficient, and in the best interests of the success of the JSF program."²² Since DOD's response to Congress in 2004, the issue of JSF program management has not been raised.

¹⁸ (...continued)

December 12, 2006.

¹⁹ See David Fulghum, "DAWG Bites; Cuts to Electronic Attack Programs and Impractical Schedules Worry US Military," *Aviation Week and Space Technology*, November 6, 2006.

²⁰ H.Rept. 108-553 (H.R. 4613), p. 234

²¹ Elizabeth Rees, "Jumper Supports Single Service Retaining JSF Acquisition Oversight," *Inside the Air Force*, August 6, 2004.

²² U.S. Department of Defense, *Report to Congress on Joint Strike Fighter Management Oversight* [forwarded by] Michael W. Wynne, Under Secretary of Defense for Acquisition, Technology and Logistics, December 20, 2004.

Funding and Projected Costs

The Defense Department's quarterly Selected Acquisition Report of December 31, 2006, estimated the JSF program at \$299,824.1 million in then-year dollars for 2,458 aircraft, which equates to a program acquisition unit cost (PAUC) of \$121.9 million per aircraft. The average procurement cost (APUC) (which does not include R&D or other costs) is estimated at \$104.4 million per aircraft. The December 2005 SAR noted that the JSF program breached a "Nunn-McCurdy" cost growth limit: unit cost growth over 30% of the original Acquisition Program Baseline.²³ The December 2006 PAUC and APUC cost estimates are, respectively, 37.9% and 37.7% higher than cost estimates made in October 2001.

The JSF program estimate has increased over \$100 billion due primarily to a one-year extension in the program's System Development and Demonstration phase, a corresponding one-year delay in procurement (from FY2006 to FY2007), revised annual quantity profiles, and revised labor and overhead rates.²⁴ Much of this increased cost and schedule slippage was incurred to address weight-driven performance issues in the development of the F-35B, the STOVL variant.

DOD's FY2008 budget requests \$6.1 billion in JSF funding. As it did in FY2007, DOD proposes to eliminate funding for the F136 Alternate Engine. The proposed termination of the F136 drew considerable scrutiny in the 109th Congress (second session). The Senate Armed Services Committee held two hearings specifically on this issue on March 14 and March 15, 2007, and the Air Land Subcommittee held a hearing on March 28, 2007. The House Armed Services Committee also addressed this issue in a March 1 hearing, as did the Tactical Air Land Subcommittee on March 22. FY2007 House-Senate conferees agreed to prohibit F136 termination pending an independent analysis of the alternate engine's potential cost savings. Those studies have been completed and submitted to Congress. The Government Accountability Office has recommended continuation of the F136 engine development based on potential return on investment along with a number of benefits. These benefits include having a second engine in case of fleet-wide grounding of the other engine and better responsiveness from competing contractors. OSD's Cost Analysis Improvement Group along with the Institute for Defense Analysis, while noting the various benefits garnered from competition, questioned the potential for monetary return on investment.²⁵

²³ JSF program breach of Nunn-McCurdy was also reported and addressed in the 2003 SAR. The FY2006 National Defense Authorization Act directed a change in reporting based on the "original" Acquisition Program Baseline resulting in a second breach of Nunn-McCurdy.

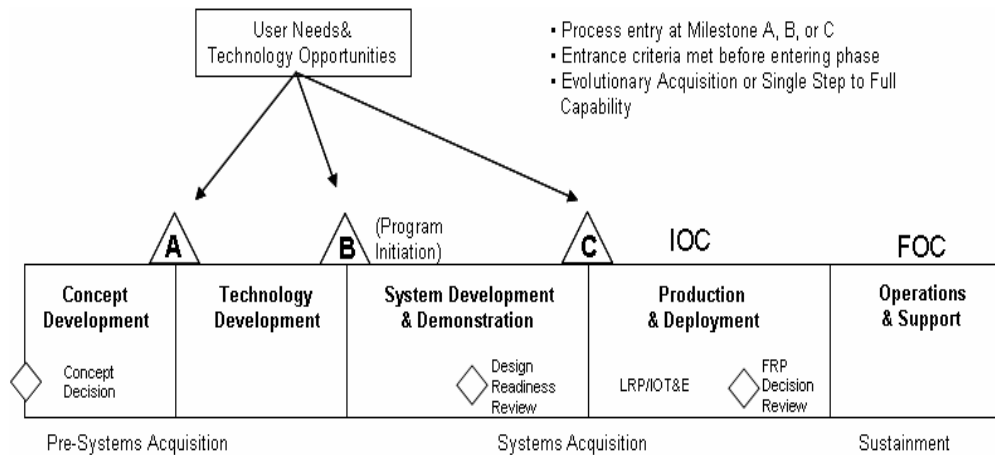
²⁴ Summaries of DOD's Select Acquisition Reports can be found at [<http://www.acq.osd.mil/ara/am/sar/index.html>].

²⁵ *Analysis of Costs for the Joint Strike Fighter Engine Program*, GAO-07-656T, March 22, 2007; *F-35/JSF Alternate Engine Acquisition and Independent Cost Analyses*, OSD CAIG Briefing, March 15, 2007; *Joint Strike Fighter (JSF) Engine Cost Analysis: Final Report*, Institute for Defense Analysis, July 2007.

Development and Schedule

The JSF is currently in the System Development and Demonstration Phase (SDD). **Figure 2**, below, from DOD Instruction 5000.2, *Operation of the Defense Acquisition System*, depicts graphically the acquisition system and where SDD fits into the process.²⁶

Figure 2. Defense Acquisition Management Framework



Until late in 2003, the JSF program’s SDD phase was scheduled to run until around 2012, at which time full rate production was scheduled to begin, with a projected initial operational capability around 2010 for USMC’s STOVL aircraft. Subsequent schedule changes have added time and cost to the program.

To address growing weight-driven performance problems encountered early in SDD, DOD extended the SDD phase one year and correspondingly delayed the F-35’s scheduled first flight from late 2005 to the summer of 2006 (first flight occurred on December 15, 2006); the beginning of low-rate initial production shifted from 2006 to 2007. Currently, SDD developmental flight testing will conclude October 2012 and the SDD contract period of performance will end a year later.²⁷ Procurement profiles in the Future Years Defense Plan (FYDP) are as follows:

	FY2008	FY2009	FY2010	FY2011	FY2012	FY2013
USAF	6 aircraft	8	12	24	42	48
USN	6	8	18	19	40	42

²⁶ JSF program milestones: Concept Development (CDP) in November 1996. Milestone B reached on October 2001, with program successfully completed the CDP exit criteria. Critical Design Review for the CTOL and STOVL variants were completed in February 2006, with the Defense Acquisition Board approving Low Rate Initial Production (LRIP) in March 2006.

²⁷ IOT&E will conclude in October 2013 bringing SDD to a close.

Initial Operational Capability (IOC) for the CTOL variant has slipped from FY2011 to FY2013. First flight of the weight optimized Air Force variant — the F-35A — is scheduled for 2009.²⁸ In June 2005, DOD officials reported that weight reduction efforts were successful and approved the revised schedule and path forward.²⁹

The 2005 National Defense Authorization Act directed the GAO to conduct annual reviews of the JSF program to assess the SDD's meeting of key cost, schedule, and performance goals.³⁰ In March 2006, the GAO issued its second report highly critical of the JSF testing and production schedule.³¹ GAO asserted that the amount of overlap between testing and production in the JSF program is risky and could lead to considerable cost growth in the future. GAO found that the JSF program will begin low-rate initial production (LRIP) in 2007, when the program will have completed less than 1% of flight tests. GAO notes that up to 424 F-35 aircraft may be built, at a cost of \$49 billion, before development testing is complete. The JSF program intends to make initial production orders on a cost reimbursement contract, "placing an unusually high risk burden on the government during the early production phase."³² GAO recommended adopting a more evolutionary approach to developing and producing the F-35, similar to the block upgrade approach pursued successfully in the F-16 program. The GAO's third report in March 2007 continues to echo the previous year's concerns of concurrency risk and cost growth.³³ GAO recommended in the latest report that DOD limit annual production quantities to no more than 24 aircraft per year until each variant's basic flying qualities have been demonstrated (Block 1 DT&E now scheduled for completion by 2010).³⁴ GAO stresses that the JSF's program has not reached the level of maturity needed to guarantee a stable aircraft design and therefore reduced risk of excessive program cost growth. GAO supports their assertions by noting that JSF total program costs have increased an estimated \$19.8 billion since 2003.³⁵

OSD countered GAO's assertions noting that GAO's recommended block development approach would extend SDD by up to eight years, with an associated

²⁸ The first F-35 to fly was dubbed AA-1, which is the pre-weight adjusted version of the CTOL variant. AF-1, the Air Force CTOL, will incorporate the weight adjustments made to bring STOVL into limits and is scheduled to fly in 2009. The first flight of the weight-optimized STOVL variant, BF-1, is scheduled for 2008 to meet USMC IOC requirements.

²⁹ Marc Selinger, "DoD Approves detailed 're-plan' for Joint Strike Fighter," *Aerospace Daily & Defense Report*, June 2, 2005.

³⁰ P.L. 108-375; 118 Stat 1833; October 28, 2004.

³¹ *Joint Strike Fighter: DoD Plans to Enter Production before Testing Demonstrates Acceptable Performance* (GAO-06-356), Government Accountability Office, March 2006.

³² *Ibid.*, p. 6.

³³ *Joint Strike Fighter: Progress Made and Challenges Remain* (GAO-07-360), Government Accountability Office, March 2007.

³⁴ *Ibid.*, p. 23.

³⁵ *Ibid.*, p. 7.

cost of approximately \$13 billion (in then-year dollars).³⁶ While GAO's approach would delay fielding of the F-35, OSD noted that there was no GAO analysis as to the costs of legacy fleet extensions or procurement price increases. The JSF Joint Program Office noted that program acquisition strategy was designed to take advantage of knowledge gained from the F-22 program and legacy programs along with improvements in modeling and simulation to reduce the development period.³⁷ While this strategy presents increased program risk, proponents note projected cost savings as a result of an expedited testing cycle and retirement of legacy systems. Proponents also highlight that fixes discovered during a more concurrent (i.e., expedited) testing/production cycle are usually much less expensive than the costs associated with a more exhaustive testing period, with less overlap and extended production period. This argument is strengthened somewhat by a Defense Aerospace case study that determined continuity in development is the best way to avoid cost overruns.³⁸ Programs that are able to manage developmental issues without lengthy program "freezes" were more apt to keep production cost growth to a minimum.

Currently, the JSF has encountered only one major issue, weight growth, that has appreciably delayed program acquisition with a significant increase in program cost. While the program has had 38% cost growth since Milestone B, 20% of that growth was encountered in 2003, with a majority of that directly attributed to the weight issue.³⁹ Additional factors such as increased use of higher cost materials (aluminum and titanium), changes in the buy profile (both the Navy's 409 aircraft reduction and the Air Force's reduction in maximum yearly buy rate), and increases in labor rates make up a large portion of the remainder of cost growth. DOD responded to GAO's reservations stating that it does not believe a major manufacturing or design flaw requiring extensive program delay is likely at this point.⁴⁰

The program slip due to weight growth also had a large impact in reducing the program's management reserve from the initial \$2 billion to \$392 million. In an effort to save money and replenish the reserve account, news reports state Lockheed proposes to eliminate test aircraft, personnel, and hundreds of test flights.⁴¹ The goal of these cost-saving measures would help bring the management reserve account back up to about \$1 billion, which is considered an acceptable amount to complete flight testing. Opponents note that such a move would add additional risk to a program already facing excessive risk with its current overlap between development

³⁶ DOD Information Paper for SASC PSM's Stan O'Connor and Creighton Greene in response to GAO-06-356, June 17, 2006.

³⁷ Background information provided by JSF Joint Program Office, September 2007.

³⁸ "Sticker Shock: Estimating the Real Cost of Modern fighter Aircraft," *Defense-Aerospace.Com*, 2006, p. 3.

³⁹ Refer to 2003 and 2006 DOD Selected Acquisition Reports on Joint Strike Fighter. Additional clarifying information provided by JSF Joint Program Office, October 2007.

⁴⁰ *Joint Strike Fighter: Progress Made and Challenges Remain* (GAO-07-360), Government Accountability Office, March 2007, p. 29.

⁴¹ Tony Capacio, "To Save Money, Lockheed Seeks JSF Testing Cuts," *Fort Worth Star Telegram*, August 30, 2007.

and production. Proponents of this move state that test flights would have been reduced regardless of the status of the management reserve account, owing to testing efficiencies gained through commonality and lab investments. While DOD is still analyzing Lockheed's proposal, a December 2006 revised procurement schedule had already reduced the number of JSFs built prior to the conclusion of SDD from 424 to 275, hence potentially reducing program risk.

The JSF is expected to remain in production at least through the 2030s. Current plans call for the JSF to be manufactured in several locations. Lockheed Martin will build the aircraft's forward section in Fort Worth, TX. Northrop Grumman will build the mid-section in Palmdale, CA, and the tail will be built by BAE Systems in the United Kingdom. Final assembly of these components will take place in Fort Worth. Italy is working with Lockheed Martin and the Joint Program Office on the potential of erecting a second final assembly and checkout facility in Italy.⁴²

Production Quantities⁴³

In 1996, preliminary planning estimated over 3,000 aircraft: 2,036 for the Air Force, 642 for the Marines, 300 for the U.S. Navy, and 60 for the Royal Navy. In May 1997, however, the QDR recommended reducing projected procurement for the U.S. armed forces from 2,978 JSF aircraft to 2,852: 1,763 for the Air Force, 609 for the Marines, and up to 480 for the Navy.⁴⁴ Thus, the program would comprise 2,912 aircraft (2,852 U.S. and 60 UK JSFs), based on these recommendations. The 1997 QDR also concluded that some 230 of the Navy's projected buy of 480 JSFs could potentially be F/A-18E/Fs, depending on the progress of the JSF program and the price of its Navy variant compared with the F/A-18E/F. Former Defense Secretary William Cohen and other DOD officials stated in May 1997 that they anticipated a "creative tension" between contractors producing the F/A-18E/F and those developing the JSF, which would result in a competitive situation similar to what occurred in the C-17 program in response to Boeing's proposed alternatives for Air Force transport planes.⁴⁵

As part of an FY2004 budget briefing, on February 3, 2003, OSD Comptroller Dov Zackheim confirmed that as part of the Navy and Marine Corps Tactical Air Integration Plan (TAI) the Navy planned to reduce JSF purchases from 1,089 to 680

⁴² Michael Sirak, "F-35 Program May Get First International Orders In Third Production Lot in 2009," *Defense Daily International*, June 22, 2007.

⁴³ See **Appendix B** for proposed procurement quantities through FY2034 (the last planned procurement year for the United States).

⁴⁴ Quadrennial Defense Review Cuts Procurement in FY1999, 2000, *Aerospace Daily*, May 20, 1997, p. 280.

⁴⁵ Vago Muradian, "'QDR Tac Air Cuts Will Save \$30 Billion,' Ralston Says," *Defense Daily*, May 20, 1997, pp. 301-302; "'F/A-18E/F Buy Depends on JSF Progress,' Cohen Tells SASC," *Aerospace Daily*, May 21, 1997, pp. 285, 288. See also CRS Issue Brief IB93041, *C-17 Cargo Aircraft Program* (out of print; for copies contact Christopher Bolkcom at 7-2577).

aircraft.⁴⁶ The Department of the Navy in 2003 followed through with its planned reduction to 680 aircraft and continues to assess the CV/STOVL mix.⁴⁷

The Air Force plans to integrate some number of Active and Reserve squadrons through its Future Total Force (FTF) concept, which would save money in part by cutting the number of aircraft needed to equip these squadrons. Also, the commitment to purchase 1,763 JSFs is based on a strategy to replace legacy aircraft (F-16s and A-10s) on a one-for-one basis. Considering the JSF's improved capabilities over today's aircraft, some say that a one-for-one strategy is not required and that fewer JSF's can do the job of a greater number of today's aircraft.⁴⁸ On the other hand, DOD's recommendation to cut 96 aircraft from the planned purchase of F-22As may discourage the Air Force from reducing the JSF purchase significantly.⁴⁹ The HASC has directed the Secretary of the Air Force to submit a report in 2008 on the feasibility and desirability of procuring F-35s for the Air National Guard to support homeland defense combat air patrol missions.⁵⁰ However, the Air Force has noted in the past that once aircraft are designated for homeland defense, it becomes very difficult to call on them for overseas deployment.⁵¹

Since the JSF is a long-term program, projected quantities are more subject to change than in the case of aircraft already in full-rate production. Near-term reductions in quantity could be made up in future years, either through increased U.S. purchases or through foreign sales. However, concerns have been raised that near-term quantity reductions could scare off foreign participation and raise the aircraft's unit price. The GAO views the budget and schedule changes to the JSF program in a more negative light. In March 2005, GAO wrote that the original business case for the aircraft "unexecutable," in large part because of decreased numbers of aircraft to be procured.⁵²

Congressional Action

The Bush Administration's FY2008 budget requested \$6.1 billion in funding for the Joint Strike Fighter. This request is summarized in **Table 1**, below.

⁴⁶ DOD News Transcript, *Undersecretary Zackheim Briefs on 2004 Defense Budget*, February 3, 2003. See also Anne Marie Squeo, "Pentagon Might Slash Its Plans to Buy Fighter Jets By About 30%," *Wall Street Journal*, March 22, 2002.

⁴⁷ Center for Strategic and Budgetary Assessments, *US Fighter Modernization Plans: Near-Term Choices*, by Steve Kosiak and Barry Watts, 2007, p. 6.

⁴⁸ Sharon Weinberger, "Air Force Considers Cuts to F-35, F/A-22," *Defense Daily*, October 17, 2003, p. 1.

⁴⁹ See CRS Report RL31673, *F/A-22 Raptor*, by Christopher Bolkcom, for more information.

⁵⁰ H.Rept. 110-146, p. 111-112.

⁵¹ John Tirpak, "For Fighters, A Moment of Truth," *Air Force Magazine*, December 2005.

⁵² GAO-05-271, March 15, 2005.

Table 1. JSF F-35 FY2008 Funding
(\$ Millions)

	USN R&D	USAF R&D	USN Proc.	USAF Proc.
Request	1,707.3	1,780.8	(6 aircraft) 1,112.5 (APCY ^a) 119.5	(6 aircraft) 1,298.1 (APCY) 123.5
House Authorization (H.R. 1585, H.Rept. 110-146)	1,822,372	1,895,874	Both Chambers approved funds as requested.	
Senate Authorization (S. 1547, S.Rept. 110-77)	1,927,672	2,001,174		
House Appropriation (H.R. 3222, H.Rept. 110-279)	2,038,872	2,137,374	Both Chambers approved funds as requested.	
Senate Appropriation (H.R. 3222, S.Rept. 110-155)	1,805,772	1,879,324		

a. APCY = Advanced Procurement (current year).

HASC approved procurement requests, but took issue with DOD's R&D plans for the JSF. As it did in FY2007, DOD proposed to cancel the F136 alternate engine. And again, HASC increased the R&D accounts by \$230 million and directed that \$480 million be used on the F136 program. Section 213 of the report requires DOD to annually fund a competitive engine program for the JSF.

SASC also directed that \$480 million in R&D be applied to fund the F136 engine. The Senate cut \$39 million from JSF R&D because of carryover of unearned award fees being held in reserve by the JSF program. The Senate noted that the JSF program was holding this award money as additional incentives for future periods and therefore in excess of FY2008 requirements.

The Bush Administration's FY2007 budget requested \$5,290.1 million (\$5.3 billion) in funding for the Joint Strike Fighter. The Air Force requested \$1,015 million in procurement funds to build five aircraft and purchase long-lead items for eight aircraft in FY2008, and \$ 1,999.1 in RDT&E funds. The Navy requested \$245 in advance procurement funds (to build eight F-35B aircraft in FY2008) and \$2,031 in RDT&E funds. Congressional action on this request is summarized in **Table 2**, below. Changes to the request are highlighted in **bold** text.

Table 2. JSF F-35 FY2007 Funding
(\$ Millions)

	USN R&D	USAF R&D	USN Proc.	USAF Proc.
Request	2,031	1,999.1	245	1,015
Authorization Bill PL 109-364 (H.R. 5122, H.Rept. 109-702)	2,200	2,170	123	921
Appropriation Bill PL 109-289 (H.R. 5631, H.Rept. 109-676)	2,172	2,138	123	489

Both authorizers and appropriators objected to DOD's plan to eliminate the F136 Alternate Engine and added JSF R&D funds to continue the program. Similarly, both authorizers and appropriators expressed concern about program risk, either explicitly or implicitly, reacting to what some to believe to be an excessive overlap between JSF testing and JSF development.

The Bush Administration's FY2006 budget requested \$5,020.0 million (\$5 billion) in funding for the Joint Strike Fighter. The Air Force requested \$152.4 million in advance procurement and \$2,474.8 million in RDT&E funds. The Navy requested \$2,393 million in RDT&E funds. Congressional action on this request is summarized in **Table 3**, below. Changes to the request are highlighted in bold text.

Table 3. JSF F-35 FY2006 Funding
(\$ Millions)

	USN R&D	USAF R&D	USAF Proc.
Request	2,393.0	2,474.0	152.4
Authorization Bill PL 109-163 (H.R. 1815, H.Rept. 109-360)	2,393.0	2,474.0	152.4
Appropriations Bill PL 109-148 (H.R. 2863, H.Rept. 109-359)	2,305.1	2,366.7	120

In cutting JSF funding, the appropriations conference report noted that "excessive program risk remains,"⁵³ and that "under the revised aircraft build sequence all of these aircraft do not require full funding prior to the beginning of fiscal year 2008."⁵⁴

⁵³ H.R. 2863 (H.Rept. 109-359), p. 418.

⁵⁴ H.R. 2863 (H.Rept. 109-119), p. 172.

Major Issues

The Joint Strike Fighter program poses a number of policy issues concerning (1) the need for such new aircraft to cope with future military threats, (2) the affordability of this program in its full-scale development and production phases, (3) the feasibility of a joint-service approach to diverse service requirements, (4) potential alternatives to the JSF, (5) the implications for the U.S. defense industrial base, and (6) Allied participation in the program.

Need for New-Generation Aircraft

Some argue that future threat scenarios will not require the combat capabilities promised by JSF aircraft. According to this view, continued production of modified versions of the Air Force F-16, the Marine Corps AV-8B, and the Navy F/A-18E/F, along with the Air Force's stealthy B-2 bombers and F-22A fighters in conjunction with sea-launched missiles and air-launched precision-guided munitions, would suffice for the most probable combat scenarios.⁵⁵ As noted above, CBO analysts considered the relative costs of several options involving greater reliance on upgrades of existing aircraft versus development and procurement of the JSF. Following the 1991 Gulf War, GAO analysts questioned the need for new-generation aircraft such as the F-22A and the F/A-18E/F, as well as the JSF, arguing that current aircraft would provide more capability than was needed, concluding that it would be unlikely that potential adversaries could prevent U.S. forces from achieving their military objectives in future conflicts.⁵⁶ Subsequent U.S. airpower dominance in Bosnia, Kosovo, Afghanistan, and Iraq may strengthen this argument.

Others argue not about a need for fifth-generation aircraft to keep our military edge, but about the numbers needed of these aircraft. Currently, DOD anticipates acquiring 2458 F-35s in total for the Air Force, Navy, and Marines. As stated previously, the Air Force intends on replacing its aging F-16s and A-10s on roughly a one-for-one basis. The Navy will purchase the F-35Cs to augment the F/A-18E/Fs, whereas the Marines will replace its AV-8B Harriers that have reached their service life limits. GAO, CBO, and various independent analysis "think-tanks" have conjectured as to what is the appropriate force structure given the quantum leap in capability that the F-35 (and F-22) gives the U.S. military. The Air Force has acknowledged that there is not a need to replace F-16s on a one-for-one basis because the JSF's capabilities and survivability.⁵⁷ The Center for Strategic and Budgetary Assessments (CSBA) noted that replacement ratios for the F-16/F-35 "in the vicinity

⁵⁵ Center for Strategic and Budgetary Assessments, *U.S. Tactical Aircraft Plans: Preparing for the Wrong Future?* by Steven Kosiak, CSBA Backgrounder, October 3, 1996, pp. 5-10.

⁵⁶ U.S. General Accounting Office, *Combat Air Power: Joint Mission Assessments Needed Before Making Program and Budget Decisions*, GAO/NSIAD-96-177, September 20, 1996, pp. 9-10. See also GAO testimony before the House National Security Committee's Subcommittees on Military Research and Development and Military Procurement, June 27, 1996. GAO/T-NSIAD-96-196, pp. 4-5 ("Forces of Potential Adversaries Are Limited and Likely Slow to Improve").

⁵⁷ John Tirpak, "Struggling for Altitude," *Air Force Magazine*, September 2006.

of 3:2 to 2:1 do not seem unreasonable.”⁵⁸ The CSBA assessment is further strengthened by recent decisions by the Air Force to extend the service life of at least 223 of the 356 A-10s still in service and to keep a number of the newest F-15s well into the 2020s.

JSF proponents argue that it would be more cost-effective to acquire new-generation aircraft than to upgrade current aircraft to such an extent that they could perform effectively after 2010, maintaining that existing planes would require major modifications at considerable cost and would provide less combat-effectiveness than a new JSF family of fighter/attack aircraft. One could surmise that the proliferation of Russian and other advanced surface-to-air and air-to-air missiles (along with advanced 4th+ generation fighters) to hostile countries is likely to continue, and could pose much more serious threats to U.S. and allied aircraft than they faced in the 1991 Gulf War. Proponents also state that aircraft “parity” with our next adversary will present an unacceptable risk to the air dominance that the U.S. military normally takes for granted. Recent training opportunities, such as Cope India 2004, in which US F-15s flew simulated dogfights against Indian Su-30s, Mirage 2000s, and MiG-21s, highlight this fact. Various news accounts note that US F-15s were defeated during many of the engagements against their Indian counterparts during this exercise.⁵⁹ Moreover, some argue, many currently operational aircraft will need to be replaced by the time JSF types could be in full production in the 2010s, when most of these planes will be over 20 years old. The difficulties of accurately predicting future conflict scenarios, JSF combat-effectiveness, and what it would cost to develop, procure, and operate these aircraft, allow for a range of conjecture and debate.

Affordability of Program

JSF program officials anticipate major savings because of a high degree of commonality in components and systems among the three versions, which are to be built on a common production line. They also expect significant savings to be achieved by basing performance requirements on trade-offs between cost and performance features, with industry and the services working together as a team. The contractors are using new technologies and manufacturing techniques that reportedly could greatly reduce the JSF’s development and production costs (e.g., wider use of composite materials in place of metal, CAD/CAM [computer-aided design/computer-aided manufacture] systems, and a recently developed plastic laminate that can be used instead of paint on the airframe).⁶⁰ However, composite materials have frequently proven more expensive than metal, raising questions about the savings actually achievable.

⁵⁸ Center for Strategic and Budgetary Assessments, *US Fighter Modernization Plans: Near-Term Choices*, by Steve Kosiak and Barry Watts, 2007, p. 45.

⁵⁹ John Tirpak, “The New Air Force Fighter Debate,” *Air Force Magazine*, September 2004.

⁶⁰ Craig E. Steidle, “The Joint Strike Fighter Program,” *Johns Hopkins APL Technical Digest*, January-March 1997, pp. 6-8, 10-13, 17-18; “Kaminski Praises Industry Response to DOD Initiatives,” *Aerospace Daily*, February 16, 1996, p. 249; Bryan Bender, “‘Paintless’ Design to Save JSF an Estimated \$3 Billion,” *Defense Daily*, July 18, 1997, p. 108.

Program officials are also counting on the availability of funding to procure the aircraft at efficient rates of production. Moreover, they expect Lockheed Martin to be able to produce the JSF at less cost than was the case with previous military aircraft, when cost controls were less compelling. For example, the F-16's production costs declined by 38% between mid-1992 and early 1997, largely because of more efficient production methods and reduced labor costs, even though production rates fell from 20 to 25 aircraft per month in 1991 to about 6 aircraft per month in 1994-1995, soon after Lockheed Martin acquired the F-16 plant in Fort Worth, Texas, from General Dynamics.⁶¹ While the JSF program's overall cost has increased about 35% from its 1997 projections, CSBA notes that, historically, procurement cost growth is greatest between the periods of entering full-scale development and the point at which it enters production.⁶² Now that the F-35 has reached its production period, some would suggest that significant cost growth is less likely.

Others doubt these optimistic forecasts, citing past experience with new aircraft programs, concern about budget deficits, and support for non-defense programs in this post-Cold War period, which might preclude procurement of the JSF at projected rates.⁶³ According to this view, we cannot afford to launch a new JSF program while having to continue buying improved and ever more expensive versions of current planes to maintain force structures during what may be a long interim if the JSF runs into technical or budgetary problems.⁶⁴ It is also argued that critical performance features may have to be traded off to make the JSF affordable enough to be procured in the quantities deemed necessary to maintain force structures.⁶⁵

Disagreements over performance and capability versus cost and affordability may threaten multi-service support of the JSF program. CBO analysts have noted that the performance/capability compromises required to achieve commonality "... could mean that the service with the most modest requirements in terms of capability (the Air Force) would have to accept a higher price and capability [compared with the F-16] than it needs so that the needs of the services with the greater capability

⁶¹ William C. Scott, "Lockheed Martin Reconstructs TAS [Tactical Aircraft Systems] Unit as 'Fighter Enterprise,'" *Aviation Week & Space Technology*, July 28, 1997, pp. 64-66.

⁶² Center for Strategic and Budgetary Assessments, *US Fighter Modernization Plans: Near-Term Choices*, by Steve Kosiak and Barry Watts, 2007, p. 14.

⁶³ For discussion of budgetary constraints and competing defense programs, see Center for Strategic and Budgetary Assessments, *U.S. Tactical Aircraft Plans: Preparing for the Wrong Future?* by Steven Kosiak, CSBA Backgrounder, October 3, 1996, pp. 4-5.

⁶⁴ Vago Muradian and John Robinson, "Public Confidence at Odds with Private Concerns about Tacair," *Defense Daily*, November 19, 1996, pp. 277; John J. Shanahan, "Should We Pay \$219 Billion for This Plane? — No, It's Squandering on Imaginary Enemies," *Christian Science Monitor*, November 25, 1996, p. 19.

⁶⁵ The difficulties of balancing performance and cost in the JSF program are discussed in detail in CBO's *A Look at Tomorrow's Tactical Air Forces*, January 1997, pp. 48-50; see also Cole, Jeff, Andy Pasztor, and Thomas E. Ricks, "The Sky, the Limit: Do Lean Times Mean Fighting Machines Will Be Built for Less?" *Wall Street Journal*, November 18, 1996, p. A1.

requirements (the Navy and Marine Corps) could be met.” They argue that if history is a guide [the TFX/F-111 being a good example], JSF planes “... are apt to be more costly than Air Force requirements might dictate, but provide less capability than the Navy might desire.” They note further that “... price increases and decreases in capability are consistent with the history of many single service programs as well,” since development programs usually provide less capability at higher prices than early estimates suggest, and they conclude that the JSF program’s success “... will depend on persuading the services to lower their expectations from the stand-alone programs they might have without the Joint Strike Fighter.”⁶⁶

While debate continues over the cost of the JSF program, there is a general consensus that the issue of the United States’ aging fighter fleet must be addressed. A Defense Aerospace analysis of the costs of fourth- and fifth-generation fighter aircraft assesses the cost of the F-35 to be comparable to the Eurofighter (a 4+ generation fighter). While authors of this study note that it is very problematic to compare cost data of various non-United States fighter aircraft (given issues such as value-added taxes and government subsidies), F-35 proponents could argue that the aircraft is reasonably priced for a fifth-generation fighter.⁶⁷

Feasibility of Joint-Service Aircraft

Those skeptical of developing aircraft to meet the needs of several services often point to the TFX program in the 1960s as a classic example of DOD’s failure to produce an aircraft that was both carrier-capable and suitable for land-based Air Force operations.⁶⁸ Analogies between TFX and JSF are rejected, however, by those who argue that TFX problems will be avoided in the JSF program by developing variants of a family of aircraft that can meet service requirements while sharing many common components and subsystems, such as engines, avionics, communications, and munitions.

Their argument is supported by a comparison of the origins of the two programs that suggests that JSF has thus far avoided the pitfalls of TFX by an apparent commitment to much better coordination of service requirements and the development of three variants for the Air Force, Navy, and Marine Corps/Royal Navy instead of one all-purpose airframe for both land- and carrier-based operations.⁶⁹ CBO analysts have noted, however, that “many defense programs begin with the expectation of joint purchases by the services, but those expectations are seldom met.” For example, in the mid-1980s the Navy and Air Force planned to buy each

⁶⁶ U.S. Congressional Budget Office, *A Look at Tomorrow’s Tactical Air Forces*, by Lane Pierrot and Jo Ann Vines, January 1997, pp. 48-50.

⁶⁷ “Sticker Shock: Estimating the Real Cost of Modern fighter Aircraft,” *Defense-Aerospace.Com*, 2006, p. 2.

⁶⁸ For background on the TFX program, which produced the Air Force’s F-111 and FB-111 strategic bombers in the 1960s, see Robert Art, *The TFX Decision — McNamara and the Military* (Boston, 1968); see also Robert Coulam, *Illusions of Choice* (Princeton, 1977).

⁶⁹ Mort Rolleston, “Learning the Lessons of TFX: the Joint Strike Fighter and Acquisition Reform,” *International Affairs Review*, Summer/Fall 1999.

other's next-generation aircraft: the Navy's Advanced Tactical Aircraft — the A-12 that was cancelled in 1991 — and the Air Force F-22A, in which the Navy has not been interested since the early 1990s. Similarly, the V-22 program began in 1981 as the J VX tilt-rotor aircraft to be used by the Army, Marine Corps, Navy, and Air Force, but the Army soon dropped out and the other services reduced their projected buys.⁷⁰

While designing an aircraft that meets both the Air Force's and the Navy's needs is challenging, the Marine Corps' STOVL requirement may be what makes or breaks this joint program because it appears the most technologically challenging variant and is a leading cost driver. The costs and complications of pursuing the STOVL variant (including reducing weight growth) are leading some to suggest that the JSF program would be more feasible and more affordable if the F-35B were cancelled. In this case, the Marine Corps would buy the CV JSF instead of the STOVL variant. It is also feared that changes to STOVL variant that are required to achieve its desired weight could reduce the level of commonality between the three variants.⁷¹ This would be detrimental to the original goal of the JSF program.

Others point out that cancelling the STOVL version of JSF is complicated by the United Kingdom's investment in the program and its requirement for a STOVL aircraft.⁷² As the only Tier I partner nation investing over \$2B so far, the UK is the only nation that has had a say as to the requirements and design choices of the F-35 program during System Development and Demonstration phase (SDD). Also, the decision to terminate the STOVL may be less likely after the 18-month program slip allowed program managers to successfully get weight growth within limits.

Multi-service support of the JSF has also been threatened by concerns on the part of some Navy officials that the costs of developing these aircraft may be too high, given the service's other funding priorities. In August 1997, the Navy began a review of JSF costs, raising questions about the service's continued support. Chief of Naval Operations Admiral Jay Johnson described this cost review as a routine exercise that in no way indicated a lack of support for the program, adding that "the Navy is committed to the Joint Strike Fighter as much as our shipmates in the Marine Corps and the Air Force."⁷³ The Air Force and the Marine Corps are the major participants in the program in terms of projected procurement; however, the Air Force is strongly committed to funding its F-22A stealth fighter/attack plane, while the Marine Corps is strongly committed to funding its V-22 tilt-rotor aircraft.

⁷⁰ U.S. Congressional Budget Office, *A Look at Tomorrow's Tactical Air Forces*, by Lane Pierrot and Jo Ann Vines, January 1997, pp. 47-48. For discussion of the V-22 program, see CRS Issue Brief IB86103, *V-22 Osprey Tilt-Rotor Aircraft Program* (out of print; available from the author at 7-2577).

⁷¹ Elizabeth Rees, "DOT&E: JSF Weight Reduction Raids Commonality Between Variants," *Inside the Air Force*, January 28, 2005.

⁷² The United Kingdom needs the STOVL design to operate off their aircraft carriers and only plans on purchasing the STOVL design for both their Air Force and Navy.

⁷³ Thomas E. Ricks, "Navy Begins to Question New Attack Jet That Air Force and Marines Support," *Wall Street Journal*, September 9, 1997, p. A4; Bender, Bryan, "Navy Says It's Fully Committed to Joint Strike Fighter," *Defense Daily*, September 12, 1997, pp. 423-424.

Perhaps concerned that the Navy and Air Force might not fully support the Joint Strike Fighter program in their long-term budget plans and that this lack of support would slow down or even jeopardize the program, former Deputy Defense Secretary Rudy de Leon issued a letter on May 2, 2000, to leaders of both departments, directing them to fully fund the tri-service fighter program. Stating that the JSF program was at a “critical juncture,” de Leon reminded the Navy and Air Force leadership that the JSF will be the “cornerstone of U.S. tactical aviation for decades to come.”⁷⁴ Such friction between the services and DOD appears to have occurred more recently. In the summer of 2006, it was reported that because of financial considerations, Navy and Marine Corps officials proposed delaying fielding the JSF for over one year.⁷⁵ DOD reportedly rejected this proposal and directed the Navy to fully fund the procurement of six JSFs in FY2008.⁷⁶

Alternatives to JSF

According to some critics of the program, the U.S. armed services have alternatives to the JSF in the Air Force F-16, the Marine Corps AV-8B, and the Navy F/A-18E/F, which could be produced in upgraded and modified versions that would maintain force structures while providing at least some of the performance capabilities promised by the JSF. Moreover, they argue that more advanced versions of current aircraft designs might be developed and procured at less cost and with less risk of delays and technological problems than an entirely new family of aircraft variants may entail. Upgraded versions of existing aircraft designs could probably also be sold to allied governments that are likely to be JSF customers.

Noting the JSF’s projected cost, as well as past experience with new aircraft programs, Congressional Budget Office (CBO) analysts have suggested options that would either cancel development of the JSF, reduce procurement of the aircraft, or alter the types developed and their distribution among the services. CBO analysts have identified a number of alternatives to developing, procuring, and using JSF aircraft as currently proposed. These alternative options include reliance on modification of current fighter/attack planes already in operation or expected to be in service soon, such as the Navy F/A-18E/F and the Air Force F-22A, as well as procuring fewer JSFs than proposed or none of these aircraft, with their place being taken by F-16s, AV-8Bs, and F/A-18E/Fs.⁷⁷

A CBO report requested by the House National Security Committee’s Subcommittee on Military Research and Development, published in January 1997, analyzed the budgetary implications of the Administration’s tactical aircraft

⁷⁴ Christopher Castelli, “Air Force, Navy Directed to Fully Fund Joint Strike Fighter Program,” *Inside the Air Force*, May 5, 2000.

⁷⁵ See, for example, Jason Sherman, “Navy, Marine Corps Propose 14-Month Joint Strike Fighter Delay,” *Inside the Navy*, August 21, 2006.

⁷⁶ Christopher Castelli, “DoD Overturns Proposal to Delay Fielding of Marine Corps JSF,” *Inside the Navy*, December 18, 2006.

⁷⁷ U.S. Congressional Budget Office, *A Look at Tomorrow’s Tactical Air Forces*, by Lane Pierrot and Jo Ann Vines, January 1997, pp. 55-71.

modernization plans in regard to the JSF, F-22A, and F/A-18E/F programs. The study evaluated one option that assumed procurement of only the 1,320 JSFs planned for Air Force through 2020 but no Marine Corps or Navy JSF versions. This was estimated to save about \$2.5 billion (FY1997 \$) in average annual procurement funding over the 2002-2020 period compared with current Administration plans, estimated to cost some \$11.9 billion annually. Another option assumed procurement of 660 STOVL variants of the JSF for the Marines and the Navy, with the Air Force using F-16s and F-15Es in lieu of JSFs and F-22As, respectively, which was estimated to save about \$4.5 billion (FY1997 \$) per year from 2002 to 2020. The study also evaluated a “share-the-pain” option that would cap procurement funding for fighter/attack planes in 2002-2020 at the same level as the historical average for Air Force and Navy fighter/attack aircraft funding from 1974 to 1997. This option would continue current development plans, but because of the JSF cost cap, would be able to purchase only about 40% of the JSFs currently planned (42% for the Air Force, 30% for the Marine Corps, and 51% for the Navy) and about 50% of planned F-22As and 58% of planned F/A-18E/Fs, with estimated average savings of \$5.6 billion per year (FY1997 \$). Each of these options presents risks and opportunities. The last option, for instance, would save \$5.6 billion (FY1997 \$) in annual procurement funding but would also result in a smaller and older fighter force with less combat capability.

The Center for Strategic and Budgetary Assessments conducted a similar analysis of JSF procurement options. Their 2007 analysis analyzed four options: (1) cancel the F-35 program, (2) reduce Air Force buy by half, (3) cancel the Navy variant (F-35C), and (4) reduce the Air Force buy by half and cancel the Navy variant.⁷⁸ CSBA calculates that the various options could save DOD between \$300M and \$3.7B over the life of the program (FY2008\$). The CSBA, commenting on the most recent CBO observation that upgraded F-16s and F/A-18E/Fs are “good enough,” states that terminating the program could have a negative effect on our deterrent ability and “a strategic mistake in the long run.”⁷⁹ Terminating the JSF program at this juncture would leave our allied program partners searching for alternative aircraft and possibly questioning the United States’ commitment to joint production programs in the future. The CSBA report, however, maintains that while program cancellation “appears weak and risky,” scaling back the program to a more affordable force structure will better match the needs of the Services.⁸⁰

Another potential alternative to the JSF is the Joint Unmanned Combat Air System (J-UCAS). The J-UCAS is being jointly pursued by the Air Force and the Defense Advanced Research Projects Agency and is still in the development stage.⁸¹ Originally designed to execute a relatively small range of missions, UAV advocates argue that the technology is evolving so rapidly that J-UCASs could soon replace

⁷⁸ Center for Strategic and Budgetary Assessments, *US Fighter Modernization Plans: Near-Term Choices*, by Steve Kosiak and Barry Watts, 2007, pp. 19-26.

⁷⁹ *Ibid.*, pp. 27-30.

⁸⁰ *Ibid.*, p. iv.

⁸¹ See CRS Report RL31014, *Unmanned Combat Air Vehicles: Issues and Outlook*, for more information on UCAVs.

manned combat aircraft, not merely augment them. This perspective remains controversial among defense analysts.

Finally, there are concerns among defense analysts and some in Congress that DOD is too wedded to shorter-range tactical fighters at the expense of a future long-range strike aircraft. The 2007 John Warner National Defense Authorization Act directed that the Air Force not retire more than 18 B-52Hs and maintain not less than 44 combat-coded B-52Hs until a long-range strike replacement aircraft has reached initial operational capability or January 1, 2018, whichever comes first.⁸² Therefore, if DOD is to follow its desires to retire more of its B-52 fleet, DOD may be developing and procuring an additional long range strike aircraft while still having up to 20 years left in its F-35 procurement plan.

Implications for U.S. Defense Industry

As DOD's largest single weapon system acquisition program, the JSF is a focal point for discussions regarding the U.S. defense industrial base. The October 2001 award of the JSF Engineering Manufacturing Development (EMD) contract to a single company (Lockheed Martin) raised concerns in Congress and elsewhere that excluding Boeing from this program would reduce that company's ability to continue designing and manufacturing fighter aircraft. This, in turn, would have a negative effect on the U.S. defense industrial base.⁸³

Similar concerns were raised in 2006 when DOD proposed terminating the F136 Alternate Engine. In this case, some worried that if the F136 were cancelled, General Electric (GE) would not have enough business designing and manufacturing fighter jet engines to continue competing with Pratt & Whitney (the manufacturer of the F135 engine) in the future. This would leave the United States dependent on only one domestic manufacturer of this class of engine. Others argued that GE's considerable business in both commercial and military engines was sufficient to sustain GE's ability to produce this class of engine in the future.⁸⁴

The JSF program could also have a strong impact on the U.S. defense industry through export. Most observers believe that the JSF could potentially dominate the combat aircraft export market much as the F-16 has. Like the F-16, the JSF appears to be attractive because of its relatively low cost, flexible design, and promise of high performance. Also, analysts note that during his first stint as Defense Secretary, Donald Rumsfeld played an instrumental role in launching the F-16 program by including foreign partners in the aircraft's development.⁸⁵ Many competitors,

⁸² H.R. 5122 (H.Rept. 109-702), p. 30.

⁸³ For more information, see CRS Report RL31360, *Joint Strike Fighter (JSF): Potential National Security Questions Pertaining to a Single Production Line*, by Christopher Bolcom and Daniel Else.

⁸⁴ For more information, see CRS Report RL33390, *Proposed Termination of Joint Strike Fighter (JSF) F136 Alternate Engine*, by Christopher Bolcom.

⁸⁵ Vago Muradian, "Coffman: JSF Critical to Preserving U.S. Leadership in World Fighter (continued...)"

including France's Rafale, Sweden's JAS Gripen, and the European Typhoon, are positioned to challenge the JSF in the fighter export market, or take its market share if the program is cancelled. Also, few countries have expressed interest in buying either the F-22A or the F/A-18E/F. The one country that has expressed interest in the F-22A, Japan, will most likely be unable to procure the F-22 because of a proposed clause in the FY2008 Appropriations bill upholding a ban on F-22 exports.⁸⁶ Instead, Japan is being redirected towards the F-35.

It can also be argued that the demand for civilian transport aircraft after 2000 will be strong enough to sustain a robust U.S. aviation industry, given the need to replace aging aircraft with quieter and more fuel-efficient planes for expanding domestic and international travel markets. For example, the worldwide fighter/attack market in 2005 has been estimated to be worth about \$13.2 billion, while the commercial jet transport market is projected to be worth about \$43.5 billion at that time. Compared with its European and Asian competitors, the U.S. aviation industry appears to be well-positioned to meet the needs of an expanding world market for civil aircraft after the turn of the century.⁸⁷ The extent to which such economic conditions may preserve an adequate U.S. defense industrial base for the development and production of combat aircraft is debatable, however, given the significant differences between civilian and military aircraft requirements and technologies.

Others fear that by allowing foreign companies to participate in this historically large aircraft acquisition program, DOD may be inadvertently opening up U.S. markets to competitors who enjoy direct government subsidies. These government subsidies could create an unfair for them relative to U.S. companies, it is argued, and the result could be the beginning of a longer-term foreign penetration of the U.S. defense market that could erode the health of the U.S. defense industrial base. In May 2004, the GAO release a report that found the JSF program could "significantly impact" the U.S. and global industrial base.⁸⁸ The GAO found that two laws designed to protect segments of the U.S. defense industry, the Buy American Act and the Preference for Domestic Speciality Metals clause, would have no impact on decisions regarding which foreign companies would participate in the JSF program. This is because DOD has decided that foreign companies that participate in the JSF program, and which have signed reciprocal procurement agreements with DOD to promote defense cooperation, are eligible for a waiver.

⁸⁵ (...continued)

Market," *Defense Daily*, February 26, 2001.

⁸⁶ "US Decides to Keep Export Ban on F-22 Stealth Fighter," Jiji Press Ticker Service, July 26, 2007.

⁸⁷ Richard Aboulafia, "Market Overviews — Commercial Jet Transports, Fighter/Attack Aircraft," *World Military and Civil Aircraft Briefing*, Teal Group Corp., March 1997.

⁸⁸ General Accountability Office, *Joint Strike Fighter Acquisition: Observations on the Supplier Base*, GAO-04-554, May 2004.

Implications for Military Bases

In October 2006, Air Force officials indicated the six tentative locations where F-35s would be based. These locations were Nellis AFB, NV; Edwards AFB, CA; Hill AFB, UT; Eglin AFB, FL; Shaw AFB, SC; and Kadena Air Base, Japan. The Air Force is now awaiting environmental studies before making a final determination. The Marine Corps has tentatively indicated that MCAS Beaufort, MCAS Yuma, MCAS Iwakuni, MCAS Miramar, and MCAS Cherry Point will be the bases for the F-35, again pending their environmental studies and approval of the basing plan.

Basing decisions for the JSF may be of interest to many in Congress. The F-35 is thought by many to be the last manned aircraft that DOD is likely to develop for some time and is projected to be in service long after other combat aircraft have been retired. Those wishing to keep military bases relevant, and to potentially “BRAC-proof” them, may compete vigorously for the JSF.

Allied Participation

Allied participation in the JSF development program has been actively pursued as a way to defray some of the cost of developing and producing the aircraft, and to “prime the pump” for export. Congress insisted from the outset that the JAST program include ongoing efforts by the Defense Advanced Research Projects Agency (DARPA) to develop more advanced STOVL aircraft, opening the way for British participation. From the Allied perspective, they saw the F-35 as an affordable avenue to acquiring a fifth-generation fighter, technical knowledge such as stealth, and industrial opportunities for domestic firms. The two JSF developmental phases where international participation has been offered are (1) Systems Development and Demonstration (SDD) and (2) Production, Sustainment and Follow-On Development (PSFD). Initial Operational Test and Evaluation (IOT&E), a subset of SDD, is another area that partner nations are assisting the program with. Within each of these phases, the level of participation and funding drives the amount of influence the respective nation can wield.

System Development and Demonstration (SDD)

Eight countries, from 2001 to 2002, signed on to the JSF program to support the anticipated 10-year SDD phase. Partnership was broken down into three levels, by the size of monetary contributions to the program. The higher the investment level, the greater the nation’s voice with respect to aircraft requirements, design, and access to technologies gained during development.

The United Kingdom is the only “Level 1” partner contributing approximately \$2 billion to this phase. UK participation actually began at program outset. On December 20, 1995, the U.S. and UK governments signed a memorandum of understanding (MOU) on British participation in the JSF program as a collaborative partner in the definition of requirements and aircraft design. This MOU committed the British government to contribute \$200 million towards the cost of the 1997-2001

concept demonstration phase.⁸⁹ On January 17, 2001, the United States and United Kingdom finalized the UK's SDD participation, which equated to approximately 8% of the total SDD program. Program proponents noted the UK's signature represented "strong international affirmation of the JSF concept," even though prime contractor competition and selection had not been completed.⁹⁰ Many UK firms, such as British Aerospace and Rolls-Royce, have strong participation in the program.

Level II partners consist of Italy and the Netherlands, contributing \$1 billion and \$800 million, respectively. On June 24, 2002, Italy became the senior Level II partner, with the goal of replacing its leased US F-16s and complimenting its Eurofighter Typhoons, and occupies five positions within the Joint Program Office.⁹¹ Italy has been pushing to have its own final assembly line, in addition to the possibility of a maintenance and upgrade facility. The Netherlands signed on to the program on June 17, 2002, after it had conducted a 30-month analysis of potential alternatives. The Dutch see their participation in JSF as a boost to its standings as a maintenance, repair, and overhaul hub in Europe.⁹²

The remaining nations of Australia, Denmark, Norway, Canada, and Turkey signed on to the JSF program as Level III partners, with contributions ranging from \$125 million to \$175 million. While contributions are less than their Level I and II partners, the benefit to all nations who participate is a strong commitment by the U.S. to export the aircraft to partner countries once the JSF is in production.⁹³ Turkish officials have stated that participation in the JSF program is a "major opportunity for our defense industry."⁹⁴

Production, Sustainment and Follow-On Development (PSFD)

Unlike the SDD phase, PSFD will not make any distinction as to "levels." In signing the PSFD MOU, partner nations state their intentions to purchase the JSF, and in what quantity and variant, and a determination is made as to their delivery schedule. The governance structure of the program has broadened to allow all participating nations to have a voice in follow-on development decisions. PSFD costs will be divided on a "fair-share" based on the programmed purchase amount of the respective nation. Also, unlike the bilateral SDD MOUs, PSFD is an agreement among all partner nations. Program executives noted the difficulty in coming to an agreement on PSFD because of the expectancy of "offset" arrangements within the

⁸⁹ "U.S., U.K. Sign JAST Agreement," *Aerospace Daily*, December 21, 1995, p. 451.

⁹⁰ Eric Tegler, "International Instrument: Building the F-35 In Partnership," *F-35 Lightning II Commemorating First Flight*, p. 71.

⁹¹ "F-35 Joint Strike Fighter (JSF) Lightning II: International Partners," [<http://www.globalsecurity.org/military/systems/aircraft/f-35-int.htm>], accessed on October 3, 2007.

⁹² Tegler, pp. 74-75.

⁹³ "Australia, Belgium Enter Joint Strike Fighter Program as EMD Partners," *Inside the Air Force*, April 21, 2000.

⁹⁴ Bekedil, Burak Ege and Umit Enginsoy, "Turks to Pay up to \$1 Billion to Join JSF Development," *Defense News*, July 17, 2000, p. 6.

agreement.⁹⁵ Offset arrangements, considered the norm in defense contracts with foreign nations, usually require additional “sweeteners” to compensate the purchasing nation for the agreement’s impact to its local workforce.⁹⁶ JSF executives decided to take a different approach, in line with the program’s goal to control costs, to avoid offsets and promote competition as much as possible. All partner nations have agreed to compete for work on a “best-value” basis and have signed the PSFD MOU.

Initial Operational Test and Evaluation (IOT&E)

Currently, the UK, Italy, and the Netherlands have agreed to participate in the IOT&E program. UK, the senior JSF partner, will have the strongest participation in the IOT&E phase. Italy and the Netherlands are contributing a far smaller amount and will take part only in the coalition concept of operations (CONOPS) validation testing.⁹⁷ Other partner nations are still weighing their option to participate. The benefits to participation are expedited acquisition of aircraft, pilot training for the test cycle, and access to testing results.

Program proponents note the economic potential that comes with participation in the program. A 2003 DOD study into international participation concluded that the potential exists for partner nations to earn between \$5 and \$40 of revenue for every \$1 invested through program contracts.⁹⁸ Current program policy to eschew offset arrangements will favor governments and corporations that take an aggressive approach to providing “best-value” bids for JSF work. On the positive side, this approach seeks to be the most cost-effective. However, partner countries that cannot compete effectively in this environment could be frustrated by the lack of contracts awarded.

Over the last couple of years, press reports have indicated that a number of partner nations have threatened to withdraw from the program because of frustrations over workshare and technology transfer issues.⁹⁹ As previously discussed, the F-35 program has attempted to break from past “offset” arrangements in an effort to keep costs down. Technology transfer has also been a problem with the United States’ first export of stealth technology. Congress, in the John Warner National Defense Authorization Act for Fiscal Year 2007, sensing United Kingdom frustrations with

⁹⁵ Tegler, p. 79.

⁹⁶ Travis Taylor, “An Empirical Evaluation of Offset Arrangements,” University of Richmond, July 2001, p. 6.

⁹⁷ Telephonic conversation with OSD/AT&L, October 3, 2007.

⁹⁸ “International Industrial Participation: A Study of Country Approaches and Financial Impacts on Foreign Suppliers,” Office of the Deputy Under Secretary of Defense (Industrial Policy), June 2003.

⁹⁹ See “Norway Signs Industrial Partnership with Eurofighter Consortium,” *Defense Daily*, January 29, 2003; Joris Janssen Lok, “Frustration Mounts Among JSF Partners,” *Jane’s Defense Weekly*, March 24, 2004; Thomas Dodd, “Danish Companies Consider Quitting JSF Programme,” *Jane’s Defence Weekly*, January 9, 2004; Tom Kingston, “Unsatisfied Italy May Cut JSF Participation,” *Defense News*, May 10, 2004; Lale Sariibrahimoglu, “Turkey may withdraw from JSF program,” *Jane’s Defence Weekly*, November 10, 2004.

technology-sharing, advised the Secretary of Defense to share technology consistent with the national security interests of both nations.¹⁰⁰ Program officials note that they are working with partner nations to improve their ability to effectively compete for JSF work and are working with DOD expedite technology-transfer issues.¹⁰¹ While workshare and technology transfer issues still remain, no country has pulled its support for the F-35 program, and all have signed the Production, Sustainment, and Follow-On Development memorandum. The issue for U.S. policy makers is how to balance legitimate yet often contradictory concerns regarding security, investment, and industrial competitiveness.

JSF program managers also offer FMS-level of participation for those countries unable to commit to partnership in the JSF's SDD phase. Israel and Singapore are believed to have contributed \$50 million each, and they are "Security Cooperative Participants." This relationship provides "specific case scope outside the cooperative development partnership."¹⁰² JSF officials have discussed the aircraft with the defense staffs of many other allied countries as prospective customers, including Germany, Greece, and Spain. The Polish government is reportedly leaning toward an FMS investment of \$75 to \$100 million in the JSF program.¹⁰³

¹⁰⁰ P.L. 109-364; 102 Stat 2134; October 17, 2006.

¹⁰¹ Tegler, p. 81.

¹⁰² Selected Acquisition Report. Office of the Secretary of Defense for Acquisition. December 31, 2005.

¹⁰³ Grzegorz Holdanowicz, "Poland Steps Up Interest in JSF," *Jane's Defense Weekly*, July 18, 2001.

Appendix A. JSF Key Performance Parameters

	KPP	STOVL	CTOL	CV
JOINT	<i>Radio Frequency Signature</i>	Very Low Observable		
	<i>Combat Radius</i>	450 nm USMC Profile	590 nm USAF Profile	600 nm USN Profile
	<i>Sortie Generation</i>	4 Surg / 3 Sust	3 Surg / 2 Sust	3 Surg / 2 Sust
	<i>Logistics Footprint</i>	< 8 C-17 equivalent loads (20 PAA)	< 8 C-17 equivalent loads (24 PAA)	< 46,000 cu ft 243 ST
	<i>Mission Reliability</i>	95%	93%	95%
	<i>Interoperability</i>	Meet 100% of critical, top-level Information Exchange Requirements Secure Voice and Data		
USMC	<i>STOVL Mission Performance</i> <i>Short Take-Off Distance</i>	550'	N/A	N/A
	<i>STOVL Mission Performance</i> <i>Vertical Lift Bring Back</i>	2 x 1K JDAM, 2 x AIM-120 With Reserve Fuel	N/A	N/A
USN	<i>Maximum Approach Speed</i>	N/A	N/A	145 knots

Notes: JSF Joint Program Office: October 11, 2007. PAA = Primary Aircraft Authorized, ST = Short Tons, Vertical Lift Bring Back = amount of weapons/fuel that can be safely landed with.

Appendix B. JSF Procurement Plan

Fiscal Year	U.S. Air Force	U.S. Navy	International	Total	Cum
2007	2	0	0	2	2
2008	6	6	0	12	14
2009	8	8	3	19	33
2010	12	18	2	32	65
2011	24	19	2	45	110
2012	42	40	30	112	222
2013	48	42	36	126	348
To 2034	1621	547	573	2741	3089

Note: *F-35 Lightning II Program Brief (April 19, 2007)*, JSF Program Office.