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## **Joint Strike Fighter (JSF) Program: Background, Status, and Issues**

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# Joint Strike Fighter (JSF) Program: Background, Status, and Issues

## Summary

The Defense Department's Joint Strike Fighter (JSF) is one of three aircraft programs at the center of current debate over tactical aviation, the others being the Air Force F-22 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. On October 26, 2001, the Lockheed Martin team was selected to develop further and to produce a family of conventional take-off and landing (CTOL), carrier-capable (CV), and short take-off vertical landing (STOVL) aircraft for the U.S. Air Force, Navy, and Marine Corps and the U.K. Royal Navy as well as other allied services. Originally designated the Joint Advanced Strike Technology (JAST) program, the JSF program is a major issue in Congress because of concerns about its cost and budgetary impact, effects on the defense industrial base, and implications for U.S. national security in the early 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 current 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 aircraft that can be produced in affordable variants to meet different operational requirements. Developing an affordable tri-service family of CTOL and STOVL aircraft with different combat missions poses major technological challenges. Moreover, 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 U.K. Royal Navy for a successor to their Harrier STOVL aircraft, and the U.S. Navy's need for a successor to its carrier-based F-14 fighters and A-6 attack planes 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. Continuing developments and related congressional actions will be reported in CRS Issue Brief IB92115, *Tactical Aircraft Modernization: Issues for Congress*, which also discusses the Air Force F-22, the Navy F/A-18EF, and the Marine Corps V-22. These aircraft and the Air Force's B-2 strategic bomber and C-17 cargo/transport plane are the most expensive U.S. military aircraft programs. (See CRS Report 95-409F, *Long-Range Bomber Facts: Background Information* by Samuel Wolfe and Dagnija Sterste-Perkins, August 8, 2000 and CRS Report RL30685, *C-17 Cargo Aircraft Program* by Christopher Bolkom, updated periodically.)

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# Joint Strike Fighter (JSF) Program: Background, Status, and Issues

## Introduction<sup>1</sup>

The Joint Strike Fighter (JSF) program is expected to develop and build a family of new-generation tactical aircraft for the Air Force, the Marine Corps, the Navy, and Britain's Royal Navy. As now projected, the JSF is the Defense Department's largest acquisition program in terms of cost and number of aircraft to be produced. Current plans call for production of 2,912 aircraft in three versions — 1,763 for the Air Force, 609 for the Marine Corps, up to 480 for the Navy and 60 for the British Navy.<sup>2</sup> Additional aircraft may be bought by Australia, Belgium, Canada, Denmark, the Netherlands, Norway and other allied governments.

The Air Force plans to purchase a conventional landing and takeoff (CTOL) version of the JSF to replace its current force of F-16s. The Marine Corps and the Royal 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.<sup>3</sup> The Navy plans to procure a carrier-capable CTOL version — termed a CV — to replace older carrier-based aircraft.

The JSF program is scheduled to begin production around 2005, with first aircraft deliveries projected to start in 2008. For years, the JSF's cost goal was an average flyaway cost of \$28-\$38 million in FY1994 dollars, depending on the service version. In November 2000, the program director revised that goal to \$31-\$38 million each.<sup>4</sup> The total program acquisition cost of the JSF program has been estimated by CBO at about \$219 billion in FY1997 dollars, including some \$22 billion

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<sup>1</sup> More information about the Joint Strike Fighter may be found at the following websites: Joint Strike Fighter Program Office [<http://www.jast.mil/>], Boeing [<http://www.boeing.com>] Lockheed Martin [<http://www.jsfteam.com/index.html>].

<sup>2</sup> Including the 2,852 U.S. aircraft recommended by the Quadrennial Defense Review in May 1997 and the 60 U.K. aircraft for the Royal Navy. By comparison, 5,054 F-4s were produced in 1959-1979; 3,805 F-5 versions in 1959-1989; and 2,960 A-4s in 1953-1979. *Jane's All the World's Aircraft*, 1980-81: 380; 1990-91: 471; 1981-82: 413.

<sup>3</sup> The U.S. Marine Corps and the U.K. Royal Navy and Royal Air Force operate versions of the AV-8A/B Harrier aircraft flown by these services since the early 1970s. See CRS report 81-180F. *The British Harrier V/STOL Aircraft: Analysis of Operational Experience and Relevance to U.S. Tactical Aviation*, August 15, 1981.

<sup>4</sup> Low-end cost of Joint Strike Fighter family raised to \$31 million. *Aerospace Daily*. November 27, 2000.

for research and development (R&D) and some \$197 billion to procure these aircraft.<sup>5</sup> Their actual costs will depend on future inflation rates, technological factors, and procurement schedules.

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 1994, the JAST program was criticized by some observers for being a technology-development program rather than a focused effort to develop and procure new aircraft. 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) aircraft was incorporated into the JAST program, which opened the way for Marine Corps and British Navy participation.<sup>6</sup> The name of the program was then changed to JSF to focus on joint development and production of a next-generation fighter/attack plane.

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.<sup>7</sup> 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 (one CTOL and one STOVL) to demonstrate their concepts for three JSF variants to meet the different operational requirements of the various services. The CTOL aircraft will demonstrate concepts for an Air Force land-based (CTOL) variant and a Navy carrier-based (CV) variant, with the STOVL aircraft demonstrating concepts for a variant to be operated by the U.S. Marine Corps and the U.K. Royal Navy. 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 production and operation and support costs.

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<sup>5</sup> U.S. Congressional Budget Office. *A Look at Tomorrow's Tactical Air Forces* by Lane Pierrot and Jo Ann Vines. January 1997: 83-87. This estimate assumed a JSF program of 2,978 aircraft (including 60 U.K. JSFs) as then projected. In May 1997, the Quadrennial Defense Review recommended 2,852 U.S. JSFs, which together with 60 U.K. JSFs would be a 2,912-plane program. Procuring fewer planes increases the unit cost of each plane but reduces the total procurement cost of the program.

<sup>6</sup> 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 U.K. 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.-U.K. collaboration in JSF development.

<sup>7</sup> Tirpak, John A. Strike Fighter. *Air Force Magazine*, October 1996: 22-28; Hough, Philip. An Aircraft for the 21<sup>st</sup> Century. *Sea Power*, November 1996: 33-34.

Mainly because of their projected costs, three tactical aircraft programs are currently subjects of debate over the types and numbers of aircraft that U.S. armed forces may need in the future — the emergent JSF program, the Air Force F-22 program now nearing production, and the Navy's F/A-18E/F program now in production. Congressional decisions on these programs will have important implications for defense funding requirements, U.S. military capabilities, and the U.S. aerospace industry.

## Program Management and Schedule

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 MGen Michael Hough (USMC). His deputy is Brig. Gen. John Hudson (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 currently in that role with an Air Force director of the program.

Funding for the program has been requested and provided mainly through Air Force and Navy research-development (R&D) budgets, with some defense-wide funding since FY1996, when DARPA's work on STOVL aircraft designs was incorporated into the JAST program. In May 1996, in response to Congressional critics, the Department of Defense (DOD) designated the Joint Strike Fighter as a major defense acquisition program, making the program's schedule and R&D cost data more accessible through the Defense Department's quarterly Selected Acquisition Report (SAR) submissions, thus facilitating Congressional oversight.<sup>8</sup>

The concept development phase of the JSF program, which began with contracts awarded in FY1994, ended on August 15, 2001. This was the deadline for the contractor teams to submit the final data on their flight tests. They were then obliged to answer questions or requests for additional information while preparing their best-and-final offers to the Pentagon by mid-September.<sup>9</sup> The Department of Defense, and ultimately Secretary of the Air Force James Roche will choose the winning design based on several criteria, including past performance, projected performance, and cost. DoD currently plans to announce its decision on October 26, 2001, approximately one year later than previously planned.

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<sup>8</sup> Weldon: Designate JSF as Major Acquisition Program. *Aerospace Daily*, May 28, 1996: 333; DOD Designates JSF as a Major Defense Acquisition Program. *Aerospace Daily*, May 31, 1996: 355.

<sup>9</sup> Katie Fairbank. "JSF Deal is Down to the Paperwork." *Dallas Morning News*. August 15, 2001.

Flight testing of concept demonstrator aircraft – at one time planned for the July 2000 time frame – ran from September 18, 2000 to July 30, 2001. The cause of the flight testing delay has been attributed to a number of factors. Some point to technical challenges, saying that the contractors had difficulty with complex software integration, and STOVL propulsion designs. Others suggest that congressional reductions in EMD funding also slowed down the program. Former DoD acquisition chief Jacques Gansler was reported to have blamed the delay in part on Congresses mandate that 20 hours of STOVL flight testing be completed prior to EMD.<sup>10</sup>

During flight testing, both contractors began by flying the Air Force variant of the aircraft, and concluded with the more technically challenging Marine Corps variant. Boeing ended its STOVL test program after 57 flights. Lockheed Martin performed 38 STOVL flights. Both contractors claimed successes. Boeing flew its demonstrator a month before Lockheed Martin's got off the ground. Lockheed said it was the first to make a short takeoff, accelerate to supersonic speed, decelerate to hover and land vertically in a single flight. Both companies touted their managerial skills as well as their technical achievements.

The JSF program's EMD phase should run until around 2008, at which time full rate production is scheduled to begin. This full-scale development phase is expected to lead to production of aircraft with a projected initial operational capability around 2010. Given the complexities of fielding three variants of the JSF design, getting such aircraft in operation by 2010 is viewed by some as optimistic in light of the experience of previous joint aircraft development programs.<sup>11</sup> Others argue, however, that new developments in technology as well as changes in perceptions of budget priorities and defense requirements might enable some JSF variants to achieve initial operating capability (IOC) by around 2010. First flight of JSF is scheduled for 48 months after contract award. The production plan for JSF includes building 22 test articles during EMD, seven of which would be non-flying and 15 flying aircraft. Full rate production is scheduled to begin in 2008.<sup>12</sup>

The JSF is expected to remain in production at least through the 2020s. In 1996, the program included 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 procurements 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.<sup>13</sup> Thus, the program would comprise 2,912 aircraft (2,852 U.S. and 60 U.K. JSFs), based on these recommendations. The 1997 QDR also concluded that some 230 of the Navy's projected buy of 480 JSFs could instead be

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<sup>10</sup> Linda de France. "Pentagon Gives JSF, F-22 Wiggle Room for Meeting Requirements." *Aerospace Daily*. October 13, 2000.

<sup>11</sup> Grossman, Elaine M. Fielding Date for JSF May Slip by One or Two Years. *Inside the Pentagon*, January 18, 1996: 3-4.

<sup>12</sup> Hunter Keeter. "Lockheed Martin, Boeing Execs Outline Priorities for Joint Strike Fighter EMD." *Defense Daily*. August 20, 2001.

<sup>13</sup> Quadrennial Defense Review Cuts Procurement in FY1999, 2000. *Aerospace Daily*, May 20, 1997: 280.

F/A-18E/Fs, depending on the progress of the JSF program and the price of its Navy variant compared to 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.<sup>14</sup>

There have been some indications, however, that like the test schedule, the production schedule could slip. For instance, the May 1997 report on the Quadrennial Defense Review noted that the program’s “maximum planned production rate of 194 aircraft [per year] will be reached in 2012 rather than 2010, easing overall modernization affordability.”<sup>15</sup> Thus, funding competition with other programs would affect annual procurement of the JSF, as has often been the case with other aircraft programs.<sup>16</sup>

## Funding and Projected Costs

The Defense Department’s quarterly Selected Acquisition Report (SAR) of June 30, 2000, estimated the development cost of the JSF at \$23.2 billion in then-year dollars,<sup>17</sup> with full-scale development or EMD (Engineering-Manufacturing Development) beginning in 2001 and continuing until 2008. An official estimate of the total program cost of the JSF — including development, procurement, and other related costs — has not been released. However, program officials have stated their “affordability goals” for flyaway cost per aircraft in FY1994 dollars: \$28 million for the Air Force CTOL variant, \$30-\$35 million for the Marine Corps STOVL variant, and \$31-\$38 million for the Navy’s CV variant (carrier-based CTOLs).<sup>18</sup> On November 26, 2000, Maj. Gen Hough, the JSF program director announced that the cost estimate for the CTOL variant had increased 10% to \$31 million per aircraft in FY1994 dollars. While this increase was due to “marketplace changes,” or higher than

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<sup>14</sup> Muradian, Vago. QDR Tac Air Cuts Will Save \$30 Billion, Ralston Says. *Defense Daily*, May 20, 1997: 301-302; F/A-18E/F Buy Depends on JSF Progress, Cohen Tells SASC. *Aerospace Daily*, May 21, 1997: 285, 288. See also CRS Issue Brief IB93041, *C-17 Cargo Aircraft Program*.

<sup>15</sup> U.S. Department of Defense. *Report of the Quadrennial Defense Review* [by] William S. Cohen, Secretary of Defense. May 1997: 46.

<sup>16</sup> U.S. Congressional Budget Office. *A Look at Tomorrow’s Tactical Air Forces* by Lane Pierrot and Jo Ann Vines. January 1997: 51-52.

<sup>17</sup> Then-year dollars include both actual expenditures in prior years and projected fundings for future years, in contrast to constant dollars of a specific fiscal year.

<sup>18</sup> DoD uses a “deflator scale” to translate then-year dollars into constant year dollars and thus account for inflation. Using these deflators to translate the JSF affordability goals from FY94 dollars to FY01 dollars generates the following cost figures: COTL variant; \$30.5 million, CV variant; \$32.7 - \$38.1 million, STOVL variant; \$33.8 million - \$41.42 million.



expected labor and over head costs, Maj. Gen Hough said that the cost estimates for the CV and STOVL variants had not changed.<sup>19</sup>

According to JSF officials, cost goals are expressed as unit flyaway costs because flyaway cost accounts for such a significant percentage of procurement cost that this would be the most relevant measure of cost for the cost/performance tradeoffs that will determine which contractor will build the JSF family of aircraft.<sup>20</sup>

In early 1997, Congressional Budget Office (CBO) analysts estimated that the total program cost of 2,978 JSF aircraft procured through the 2020s would be about \$219 billion in FY1997 dollars, including projected procurement costs of \$197.3 billion, development costs of \$21.5 billion, and some \$200 million in military construction costs. Each JSF would thus have an estimated program unit cost of \$73.5 million in FY1997 dollars. This analysis suggested that the JSF program's "affordability goals" for unit prices might be optimistic. For example, CBO analysts assumed in their estimate that the JSF's stealth features will entail some cost penalties in both development and production of these aircraft, which DOD's estimates appear not to take into account.<sup>21</sup>

As a new program just getting underway, the JSF's annual budget requests have been modest compared to those of the F/A-18E/F and F-22 programs, which are at more advanced stages; e.g., the FY2002 defense budget, requested \$1.5 billion in Navy and Air Force R&D funding for the JSF, compared to \$3.9 billion to procure 13 F-22 Raptors, \$3.1 billion to procure 48 F/A-18E/F Super Hornets,

In its March 22, 1996, request for proposals for concept demonstration, the program office projected JSF funding requirements totaling \$2.2 billion in FY1997-FY2000.<sup>22</sup> The concept demonstration contracts announced on November 16, 1996, totaled \$2,212.6 million (\$718.8 million to Lockheed Martin; \$661.8 million to Boeing; and \$832 million to Pratt & Whitney for engine-related work). As a collaborative partner in the JSF program, the British government agreed to provide some \$200 million during the 1997-2001 concept demonstration phase.

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<sup>19</sup> "Low-end cost of Joint Strike Fighter family raised to \$31 million." *Aerospace Daily*. November 27, 2000.

<sup>20</sup> Capaccio, Tony. JSF Office Details Development Cost Issues. *Defense Week*, May 5, 1997: 5. Flyaway cost includes only the procurement costs of airframes, engines, and avionics; it does not include the costs of equipment and manuals to maintain the aircraft, simulators for pilot training, and initial spare parts, and it excludes R&D costs and any military construction costs for special facilities. Thus, flyaway cost understates the actual cost of an aircraft, which is more fully expressed as program or acquisition cost, which includes all of the items noted above.

<sup>21</sup> U.S. Congressional Budget Office. *A Look at Tomorrow's Tactical Air Forces* by Lane Pierrot and Jo Ann Vines. January 1997: 83-87.

<sup>22</sup> Projected annual requirements were \$400 million (FY97), \$720 million (FY98), \$700 million (FY99), and \$400 (FY00). Joint Strike Fighter RFP Shows Increased USAF Buy. *Aerospace Daily*, March 25, 1996: 455.

## Congressional Action

The Administration's FY2003 budget request included \$3.5 billion in funding for the Joint Strike Fighter.<sup>23</sup>

### FY2002

Reflecting their plan to move the JSF into the EMD phase in October 2001, the Administration's \$1.5 billion FY2002 request for JSF funding was entirely in the EMD account. Expressing their support for the program, but also their doubt that the DoD would be prepared to enter JSF EMD on schedule, the Senate Armed Services Committee reduced EMD funding. Concept development funds were increased to keep contractor teams together, but the net authorization was a reduction of \$247.2 million. House authorizers supported the Administration's request, and increased it by \$10 million to reduce development schedule risk of JSF alternate engine common hardware components. Authorization conferees (S. 1438, S.Rept. 107-333) supported the Administration's request for EMD funding. Conferees also expressed their concern regarding industrial base issues and

direct the Under Secretary of Defense for Acquisition, Technology, and Logistics to submit a report, with the sub-mission of the fiscal year 2003 budget request, which details: (1) projections for the military aircraft industrial base, to include foreign military sales, between now and fiscal year 2015; and (2) actions taken by the DOD to encourage teaming arrangements in the JSF program that make the most efficient use of the expertise in the industrial base.<sup>24</sup>

Following Senate authorization, Senate appropriators transferred \$30 million from EMD to concept development in anticipation of a delay in the downselect. Senate appropriators also recommended a \$247.2 million reduction to the request, evenly split between the Navy and Air Force. House authorizers supported the Administration's plan as requested. In their report H.R. 3338 (107-350), appropriations conferees matched the Administration's request for JSF EMD funds, and increased the Navy's account by \$2.5 million for the Alternate Engine Program.

### FY1994 - FY2001

From FY1994 to FY2001 Congress provided funding within about \$329 million of the approximately \$4.3 billion requested by the Administration. Congress imposed its largest funding cut in FY2001 (\$168 million), but provided more than requested in fiscal years 1998, 1999, and 2000.

Over this time period, Congress has consistently expressed concern regarding the following issues (1) the pace of the JSF program, (2) it's affordability in the

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<sup>23</sup> "Department of Defense FY2003 Budget Program Acquisition Costs. *Aerospace Daily*. February 5, 2002. P.6.

<sup>24</sup> 107<sup>th</sup> Congress, 1<sup>st</sup> Session. U.S. House of Representatives. Report 107-333 (S. 1438) National Defense Authorization Act for Fiscal Year 2002. Conference Report. December 12, 2001. p.574.

context of overall DoD tactical aviation modernization, (3) the ability to procure a joint aircraft with widely different STOVL and COTL flight parameters, and (4) the JSF program's lack of synchronization with the 1997 Quadrennial Defense Review (QDR).

The Senate Appropriations Committee recommended FY1997 funding for the JSF as requested, but the Committee questioned "the current pace of the Joint Strike Fighter program, given the costs to continue it, the potential for cost growth, and the need to fund other service priorities now and in the future."<sup>25</sup>

**Table 1. JAST/JSF Funding**  
(in millions of then year dollars)

	<b>Request</b>	<b>Appropriation</b>
FY1994	50	29.7
FY1995	201.4	182.1
FY1996	331.2	190.2
FY1997	589	571
FY1998	930.9	945.9
FY1999	919.5	927
FY2000	476.6	491.6
FY2001	856.7	688.6
FY2002	1,536.7	1,539.2
<b>Total</b>	<b>5892</b>	<b>5565.3</b>

Concerns about the significantly different flight parameters of conventional and STOVL aircraft were reflected in the House version of the FY1997 defense authorization bill, which denied funding for a STOVL variant of the JSF (H.R. 3230, Sec. 220), thus precluding participation by the U.S. Marines and U.K. Royal Navy in the program.<sup>26</sup> The language denying funds for a STOVL aircraft was not included in the conference version of the FY1997 defense authorization bill, but the conferees retained a House provision calling for a report detailing force structure requirements for projected threats in 2000-2025 as well as alternative force mixes of aircraft and

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<sup>25</sup> U.S. Congress. Senate Appropriations Committee. FY1997 Defense Appropriation Act; report on S. 1894. Washington, U.S. Govt. Print. Off., 1996. 104<sup>th</sup> Congress, 2<sup>nd</sup> session. S.Rept. 104-286: 99.

<sup>26</sup> Robinson, John and Sheila Foote. Management Concerns Drove Critical JSF Language, Weldon Says. *Defense Daily*, May 9, 1996: 236-237. See also in *Congressional Record*, May 14, 1996: H4933-H4934 and H2939 the remarks of Rep. Douglas Peterson and Rep. Paul McHale in opposition to language in Section 220 denying funding for STOVL versions.

munitions and the estimated costs, operational effectiveness, and delivery schedules of these weapon systems. (H.Rept. 104-724: 37-38).<sup>27</sup>

When considering the FY1998 defense budget request, Congress discussed the JSF program as well as the F-22 and F/A-18E/F programs in terms of their long-term affordability rather than specific preferences among these three programs. When language directing the Defense Department to indicate a preference in case of insufficient funds for all three programs was proposed during Senate debate on the defense authorizations bill, the provision was soundly defeated.

The House National Security Committee's<sup>28</sup> FY1998 authorization report directed the Defense Department by February 15, 1998, to provide details on funding for full development and flight testing of an alternative engine for the JSF. In recommending decreased Air Force R&D funding, the report noted the Committee's concern "that the current pace of tactical aviation programs is both unaffordable and not coordinated with the ... Quadrennial Defense Review."<sup>29</sup>

Congressional action on the JSF in FY2001 again raised concerns about schedule and affordability. Specifically, more than one committee voiced concern regarding the acquisition strategy. Some were concerned that DoD would abandon its "winner take all strategy" and split the award of the EMD contract between the leading candidates. While this strategy might prove beneficial to the U.S. aerospace industrial base in the long run, legislators opined that it would significantly raise JSF costs. Appropriations conferees (H.R. 4576, H.Rept.106-754. p. 220) endorsed DoD's winner take all strategy, and wrote that "...industrial base concerns can best be addressed after the source selection decision." Also, more than one committee raised concerns about the maturity of key JSF technologies and whether the program was ready to graduate from the demonstration/validation phase to EMD as per DoD plans.

Reflecting a three month delay in moving the JSF program to the EMD phase, appropriations conferees cut the FY2001 EMD request by \$393 million, and increased concept development funds, for a net reduction to the program of \$168 million. The conferees also directed that all flight testing – including at least 20 hours for the STOVL design – should be completed and fully evaluated prior to the selection of a JSF EMD design (H.R. 4205, p. 717).

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<sup>27</sup> The Defense Department's Institute for Defense Analysis (IDA) provided the defense committees information and periodic briefings in response to these questions during 1996-1997. Conversations with Dr. Dean Simmons, IDA, August 21 and November 4, 1997.

<sup>28</sup> The House National Security Committee was renamed the House Armed Services committee in January 1999.

<sup>29</sup> U.S. Congress. House National Security Committee. FY1998 National Defense Authorization Act; report on H.R. 1119. Washington, U.S. Govt. Print. Off., 1997. 105<sup>th</sup> Congress, 1<sup>st</sup> session. H.Rept. 105-132: 189-190, 212, 243.

## Designs and Performance Capabilities

Contrary to some misconceptions that the Joint Strike Fighter would be one aircraft used by several services for different missions, the program envisions the development and production of three highly common variants: a land-based CTOL version for the Air Force, a carrier-based CTOL version (CV) for the Navy, and a STOVL version for the Marines and the Royal Navy. Thus, the two contractors, Boeing and Lockheed Martin, are to demonstrate competing designs for a family of such aircraft, which use a mix of components, systems, and technologies with commonality projected at 70 to 90 percent in terms of production cost. As currently envisioned, the designs will have many high-cost components in 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."<sup>30</sup>

The overall Boeing design has been described as the more innovative, featuring a solid wing (with considerable space for internal-fuel) and a single direct-lift engine with nozzles for vectored thrust in STOVL operations (similar to the AV-8 Harrier's Pegasus engine). The Lockheed Martin design is generally described as more conservative, resembling Lockheed's F-22 stealth aircraft. However, the Lockheed STOVL concept which employs a shaft-driven lift fan connected to the main engine with extra thrust provided by vectoring nozzles, is the less traditional approach. The design proposed by the McDonnell Douglas, Northrop Grumman, and British Aerospace team was an almost tailless aircraft, powered by separate lift and lift/cruise engines. The use of separate engines was reportedly a factor in the rejection of this design.<sup>31</sup>

Both of the competing airframe designs will be powered by engines derived from the F-22's Pratt & Whitney F119 power plant, with a General Electric F120 derivative to be developed as a competing alternative engine.<sup>32</sup> The engines of both designs will include components made by Allison (now owned by Rolls-Royce, which developed and produced the Pegasus engines powering Harrier STOVL aircraft since the 1960s). The JSF program would benefit from the broad engineering experience and the competitive environment provided by Pratt & Whitney, General Electric, and

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<sup>30</sup> 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

<sup>31</sup> Sweetman, Bill. Decision Day Looms for Joint Strike Fighter. *Jane's International Defense Review*, September 1996: 36-39, 42-43; Bender, Bryan and Tom Breen. Boeing, Lockheed Martin Win JSF Demonstrator Contracts. *Defense Daily*, November 18, 1996: JSF special report.

<sup>32</sup> Sweetman, Bill. Vectored Thrust Takes Off, Competition for JAST's Engine Design Grows. *Jane's International Defence Review*, April 1996: 30-32, 35-36, 39; Goodman, Glenn W. The Second Great Engine War. *Armed Forces Journal International*, April 1996: 18; Warwick, Graham. GE YF-120 Wins the Vote as JSF Competitive Engine. *Flight International*, May 22-28, 1996: 17; Allison Unit Eyes JSF Alternate Engine Deal. *Aerospace Daily*, November 21, 1996: 1-3 (Aerospace Propulsion Extra section); JSF Alternate Fighter Engine Program Fleshing Out. *Aerospace Daily*, May 20, 1997: 279.

Allison/Rolls-Royce, but despite potential savings through competition the development of an alternative power plant would significantly increase the JSF's development cost. For this reason, there has been some opposition in the Defense Department to an alternate JSF engine, although there has been considerable support in Congress since 1996.<sup>33</sup>

All JSF planes will be single-engine, single-seat aircraft with supersonic dash capability and some degree of stealth (low observability to radar and other sensors). Combat ranges and payloads will vary in the different service variants. For example, as currently planned, range requirements would be 450-600 nautical miles (nmi) for the Air Force, 600 nmi for the Navy, and 450-550 nmi for the Marine Corps. As projected in late 1997, Air Force and Navy versions would carry two 2,000-lb weapons internally, with the STOVL versions for the Marine Corps and the Royal Navy carrying two 1,000-lb weapons internally. All versions will also carry AIM-120 AMRAAMs (advanced medium-range air-to-air missiles, with a range of about 26 nmi/48 km depending on altitude<sup>34</sup>). Space will be reserved for an advanced gun, if one is found that meets operational requirements at an affordable cost.<sup>35</sup> JSF requirements dictate that the aircraft's gun must be able to penetrate lightly armored targets. Both contractors favor a 27-millimeter cannon made by the German company Mauser, which is used by many European fighter programs.<sup>36</sup>

Performance features in regard to radar signature, speed, range, and payload will be determined on the basis of trade-offs between performance and cost, with the latter being a critical factor. Program officials have emphasized that such cost and performance tradeoffs are critical elements of the current development phase, since these tradeoffs will be the basis for the joint-service operational requirements that will determine the selection of a single contractor team for the EMD phase of full-scale development to begin in 2001.<sup>37</sup> The 1997 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."<sup>38</sup> In other words, production costs must be low enough that these aircraft can be bought in sufficient quantities to maintain

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<sup>33</sup> Dual Engine Development Could Saddle JSF with up to \$800 Million Bill. *Inside the Navy*, August 5, 1996: 2; Despite Demand for Second JSF Engine Source, F120 Comes up Short. *Aerospace Daily*, October 18, 1996: 102; U.S. Congressional Budget Office. *A Look at Tomorrow's Tactical Air Forces* by Lane Pierrot and Jo Ann Vines. January 1997: 53.

<sup>34</sup> Zaloga, Steven J. AIM-120 AMRAAM in *World Missiles Briefing*. Teal Group Corp., January 1997: 5.

<sup>35</sup> Advanced Gun Seen Likely for Some Joint Strike Fighters. *Aerospace Daily*, May 5, 1997: 195. Appendix C provides further details on JSF operational/performance and cost requirements as projected in late 1997.

<sup>36</sup> Adam Hebert. "Strike Fighter Gun Choice Signals New Era For U.S. Aircraft Cannon." *Inside the Air Force*. October 27, 2000.

<sup>37</sup> Tradeoffs Will Be Made to Contain JSF Costs. *Aerospace Daily*, September 26, 1997: 469.

<sup>38</sup> U.S. Department of Defense. *Report of the Quadrennial Defense Review* [by] William S. Cohen, Secretary of Defense. May 1997: 46.

desired force levels. Thus, the parameters of the JSF's performance and operational capabilities are subject to change for reasons of cost, technological developments, and future threat assessments.

## Foreign Sales and Allied Participation

Potential foreign sales and allied participation in the JSF program have been actively pursued as a way to defray some of the cost of developing and producing the aircraft. 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.

Various contractual relationships with allied governments and foreign firms are possible, depending on the amount of funding invested in the program, ranging from the British government's participation as a collaborative partner to associate partners, informed customers, observers or FMS participants. On December 20, 1995, the U.S. and U.K. 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.<sup>39</sup> British Aerospace, Rolls-Royce, and other U.K. defense firms that have long been involved in major U.S. aircraft programs are expected to be subcontractor participants in the JSF program.<sup>40</sup> On January 17, 2001 the United States and the United Kingdom signed an MOU that committed the British government to spend \$2 billion supporting the JSF EMD phase. Britain's investment equates to approximately eight percent of the EMD program, and has been described by many analysts as a boon for the JSF program. Britain's – and other allies' – participation in the program makes it much more difficult for Congress or the Administration to cancel the program, they say.<sup>41</sup> In his nomination hearing, DoD acquisition chief Pete Aldridge testified that the any decision on the fate of the JSF would have to weigh its “international implications.”<sup>42</sup>

On April 16, 1997, the Dutch and Norwegian governments signed an MOU, which was later signed by the Danish government on September 10, 1997, committing a total of \$32 million from these NATO allies, who see the JSF as a replacement for the F-16 fighters they have operated since the late 1970s. On January 2, 1998, the Canadian government signed an MOU agreement, committing \$10 million to the JSF

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<sup>39</sup> U.S., U.K. Sign JAST Agreement. *Aerospace Daily*, December 21, 1995: 451.

<sup>40</sup> Since the 1970s many European and Japanese firms have been major participants in U.S. aircraft, avionics, and munitions programs as subcontractors or affiliates of U.S. firms; e.g., F-15, F-16, AV-8, F/A-18, and AWACS programs.

<sup>41</sup> Greg Schneider. “Britain Backs Joint Strike Fighter Effort.” *Washington Post*. January 18, 2001. “British commitment seen as major boost to the Joint Strike Fighter.” *Inside the Air Force*. January 19, 2001.

<sup>42</sup> Marc Selinger. “JSF decision should weigh ‘international implications,’ nominee for acquisition post says. *Aerospace Daily*. April 27, 2001.

program as an observer of its management innovations. Canadian officials have stated that there is no commitment to buy the aircraft, however, and that Canada does not expect the JSF to replace its F/A-18A/Bs (operated as the CF-118A/B since the early 1980s).<sup>43</sup>

On April 21, 2000 it was reported that DoD had extended offers to Australia and Belgium to become “partners” in the JSF development. Both countries declined the offer. Turkey, Italy, Denmark, Norway and the Netherlands, however have accepted partner status in the JSF EMD phase. While the exact details are still to be determined, participation in EMD is expected to cost each country from \$250 million to \$1.25 billion over 11 years. The smallest financial input a country can make to be a JSF partner is 1-2 percent of EMD cost.<sup>44</sup> The main benefit derived from participation is a strong commitment by the U.S. to export the aircraft to partner countries once the JSF is in production.<sup>45</sup> Another benefit of participation could be the transfer of military aviation expertise. Turkish officials have stated that participation in the JSF program is a “major opportunity for our defense industry.”<sup>46</sup>

In early February 2002, Canada and the Netherlands joined Britain as foreign partners in the JSF’s SDD phase. As a “Level III” partner, Canada pledged to provide \$150 million over the next 10 years for the system development and demonstration phase.<sup>47</sup> The Netherlands committed \$800 million to the program, making it a “Level II partner.”<sup>48</sup> The Dutch parliament must approve Prime Minister Kok’s decision.

JSF program managers are now offering an FMS level of participation for those countries unable to commit to partnership in the JSF’s EMD phase. JSF officials have discussed the aircraft with the defense staffs of many allied countries as prospective customers, including Germany, Israel, Italy, Turkey, Singapore and Spain. Britain’s Royal Air Force (RAF) as well as its Royal Navy may also buy some JSF aircraft over the long run. In the near term, however, the RAF is expected to buy the Eurofighter, which is to be produced by British, German, Italian, and Spanish companies as

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<sup>43</sup> Conversations with Canadian Embassy officials, February 13, 1998; Canada, U.S. Sign MOU for JSF Program. *Navy News and Undersea Technology*, February 9, 1998:7; *Joint Strike Fighter: Opportunities for Canadian Industry*. Report prepared by BDM International, Inc. for the Government of Canada, March 1997: 15p.

<sup>44</sup> Robert Wall. Pentagon Broadens Foreign Options for JSF. *Aviation Week & Space Technology*. June 5, 2000: 46.

<sup>45</sup> Australia, Belgium Enter Joint Strike Fighter Program as EMD Partners. *Inside the Air Force*. April 21, 2000.

<sup>46</sup> Bekedil, Burak Ege and Umit Enginsoy. Turks to Pay up to \$1 Billion to Join JSF Development. *Defense News*. July 17, 2000:6.

<sup>47</sup> Jim Garomone. “Canada Joins Joint Strike Fighter Effort. *American Forces Press Service*. February 7, 2002.

<sup>48</sup> “Dutch Government Decides to Join Joint Strike Fighter.” *Defense Daily*. February 11, 2002.



Europe's next-generation fighter/attack plane.<sup>49</sup> The Polish government is reportedly leaning toward an FMS investment of \$75 to \$100 million in the JSF program.<sup>50</sup>

On January 8, 2002 it was reported that the House Government Reform national security subcommittee had tasked the General Accounting Office to study the JSF program and determine if there were any disadvantages to the robust participation of foreign countries. While foreign participation is viewed as a positive means of encouraging interoperability, legislators were concerned that it could also result in excessive transfer of technology.<sup>51</sup>

## 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-22, 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.<sup>52</sup>

A CBO report requested by the House National Security Committee's Subcommittee on Military Research and Development and published in January 1997 analyzed the budgetary implications of the Administration's tactical aircraft modernization plans in regard to the JSF, F-22, and F/A-18E/F programs. The study

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<sup>49</sup> Michael J. Witt. Britain's Air Force Considers JSF as Harrier Follow-on. *Defense News*, January 12-18, 1998: 1, 27. Scott, Richard and Nick Cook. UK Air, Naval Forces Sign on Joint Future Aircraft. *Jane's Defence Weekly*, January 7, 1998: 3.

<sup>50</sup> Grzegorz Holdanowicz. "Poland Steps Up Interest in JSF." *Jane's Defense Weekly*. July 18, 2001.

<sup>51</sup> Selinger, Marc. GAO asked to review JSF international participation. *Aerospace Daily*. January 8, 2002.

<sup>52</sup> U.S. Congressional Budget Office. *A Look at Tomorrow's Tactical Air Forces* by Lane Pierrot and Jo Ann Vines. January 1997: 55-71.

evaluated one option that assumed procurement of only the 1,320 JSFs planned for Air Force buys through 2020 but no Marine Corps or Navy JSF versions; this was estimated to save about \$2.5 billion FY1997 dollars in average annual procurement funding over the 2002-2020 period compared to 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-22s, 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 it 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-22s and 58% of planned F/A-18E/Fs, with estimated average savings of \$5.6 billion (FY1997 \$) in annual procurement funding. 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.

## 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 after 2000, (3) the feasibility of such a joint-service approach to diverse service requirements, and (4) the implications for the U.S. defense industrial base.

### 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-22 fighters in conjunction with sea-launched missiles and air-launched precision-guided munitions would suffice for the most probable combat scenarios.<sup>53</sup> As noted above, CBO analysts considered the relative costs of several options involving greater reliance on upgrades of existing aircraft vs. development and procurement of the JSF. GAO analysts have also questioned the need for new-generation aircraft such as the F-22 and the F/A-18E/F as well as the JSF, arguing that current aircraft would provide more capability than was needed during the 1991 Gulf War and concluding that it would be unlikely

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<sup>53</sup> Center for Strategic and Budgetary Assessments. *U.S. Tactical Aircraft Plans: Preparing for the Wrong Future?* by Steven Kosiak, CSBA Backgrounder, October 3, 1996: 5-10.

that potential adversaries could prevent U.S. forces from achieving their military objectives in future conflicts.<sup>54</sup>

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. In this view, the proliferation of Russian and other advanced surface-to-air and air-to-air missiles to hostile countries is likely to continue, which would pose much more serious threats to U.S. and allied aircraft than they faced in the 1991 Gulf War. Moreover, 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 about twenty years old, according to defense analyst Lawrence Korb, who recommends reducing procurement of F-22s and F/A-18E/Fs in order to fund the JSF program.<sup>55</sup> Given the difficulties of accurately predicting what might be needed in future conflict scenarios, how combat-effective JSF aircraft would be, and what it would cost to develop, procure, and operate these aircraft, any analyses of military requirements and the combat effectiveness and budgetary costs of such new-generation aircraft allow for a range of conjecture and debate.

## Affordability of Program

JSF program officials anticipate major savings due to 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 tradeoffs between cost and performance features, with industry and the services working together as a team. The contractors are expected to use 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.<sup>56</sup> Composite materials have frequently proven more expensive than metal, raising questions about the savings to be achieved via composites.

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<sup>54</sup> 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: 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: 4-5 ("Forces of Potential Adversaries Are Limited and Likely Slow to Improve").

<sup>55</sup> Korb, Lawrence J. Should We Pay \$21 Billion for This Plane? — Yes, It's a Bargain for the Future. *Christian Science Monitor*, November 25, 1996: 19.

<sup>56</sup> Steidle, Craig E. The Joint Strike Fighter Program. *Johns Hopkins APL Technical Digest*, v. 18, no. 1, January-March 1997: 6-8, 10-13, 17-18; Kaminski Praises Industry Response to DOD Initiatives. *Aerospace Daily*, February 16, 1996: 249; Bender, Bryan. 'Paintless' Design to Save JSF an Estimated \$3 Billion. *Defense Daily*, July 18, 1997: 108-109.

Program officials are also counting on the availability of adequate funding to procure the aircraft at efficient rates of production. Moreover, they expect either Boeing or 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 due to more efficient production methods and reduced labor costs, even though production rates fell from 20 to 25 aircraft per month in 1991 to about six aircraft per month in 1994-95, soon after Lockheed Martin acquired the F-16 plant in Fort Worth, Texas, from General Dynamics.<sup>57</sup> Similarly, Boeing's experience in high-volume production of commercial transport planes is expected to facilitate cost-efficient production of military aircraft such as the JSF.<sup>58</sup>

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.<sup>59</sup> 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.<sup>60</sup> It can also be 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.<sup>61</sup>

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 to the F-16] than it needs so that the needs of the services with the greater capability requirements (the Navy and Marine Corps) could be met." They argue that if history is a guide, 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

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<sup>57</sup> Scott, William C. Lockheed Martin Reconstructs TAS [Tactical Aircraft Systems] Unit as 'Fighter Enterprise.' *Aviation Week & Space Technology*, July 28, 1997: 64-66.

<sup>58</sup> Schneider, Greg. Boeing Aftershocks. *The [Baltimore] Sun*, December 22, 1996: 1D, 3D.

<sup>59</sup> 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: 4-5.

<sup>60</sup> Muradian, Vago and John Robinson. Public Confidence at Odds with Private Concerns about Tacair. *Defense Daily*, November 19, 1996: 277; Shanahan, John J. Should We Pay \$219 Billion for This Plane? — No, It's Squandering on Imaginary Enemies. *Christian Science Monitor*, November 25, 1996: 19.

<sup>61</sup> 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: 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: A1.

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."<sup>62</sup>

## 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 as well as suitable for land-based Air Force operations.<sup>63</sup> 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 an analyst who compared the origins of the two programs and concluded 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.<sup>64</sup> 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 other's next-generation aircraft: the Navy's Advanced Tactical Aircraft — the A-12 that was cancelled in 1991 — and the Air Force F-22, in which the Navy has not been interested since the early 1990s. Similarly, the V-22 program began in 1981 as the JVX 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.<sup>65</sup>

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. At one point, some senior Air Force and Navy officials expressed interest in the JSF's STOVL variant, which these services might use if developments in propulsion technology result in STOVL aircraft with the range, payload, and

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<sup>62</sup> U.S. Congressional Budget Office. *A Look at Tomorrow's Tactical Air Forces* by Lane Pierrot and Jo Ann Vines. January 1997: 48-50.

<sup>63</sup> For background on the TFX program, which produced the Air Force's F-111 and FB-111 strategic bombers in the 1960s, see Art, Robert. *The TFX Decision — McNamara and the Military*. Boston, 1968; see also and Coulam, Robert. *Illusions of Choice*. Princeton, 1977.

<sup>64</sup> Rolleston, Mort. *Learning the Lessons of TFX: the Joint Strike Fighter and Acquisition Reform*. Unpublished manuscript by Master of Arts graduate in Security Policy Studies, Elliot School of International Affairs, George Washington University, February 1997.

<sup>65</sup> U.S. Congressional Budget Office. *A Look at Tomorrow's Tactical Air Forces* by Lane Pierrot and Jo Ann Vines. January 1997: 47-48. For discussion of the V-22 program, see CRS Issue Brief IB86103, *V-22 Osprey Tilt-Rotor Aircraft Program*.

supersonic speed that Air Force and Navy operators consider necessary.<sup>66</sup> Air Force and Navy procurement of STOVL as well as CTOL versions of the JSF would reduce the unit costs of these aircraft, with favorable implications for the program's affordability and multi-service support in the annual competition for funding.

The costs and complications of pursuing the STOVL variant, however, are the impetus behind a Navy suggestion that it be cancelled, and that the Marine Corps buy the CV JSF instead. Contractors counter, however, that early STOVL technical challenges have been overcome.<sup>67</sup> Others point out that cancelling the STOVL version of JSF is complicated by the UK's investment in the program. Regardless, DoD is studying the incorporation of Marine Corps fixed wing aviation into the Navy, which would eliminate the requirement for STOVL.<sup>68</sup>

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."<sup>69</sup> 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-22 stealth fighter/attack plane while the Marine Corps is strongly committed to funding its V-22 tilt-rotor aircraft. 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."<sup>70</sup>

## Implications for U.S. Defense Industry

Some fear that those firms selected as prime contractors for both development and production of the JSF (Boeing or Lockheed Martin for the airframe and Pratt &

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<sup>66</sup> Caires, Greg and Tom Breen. Global Power Office to Push for STOVL Version of JSF. *Defense Daily*, May 1, 1997: 184.

<sup>67</sup> Adam Hebert. "Early STOVL-Variant Challenges Are In The Past, JSF Contractors Say." *Inside the Air Force*. March 16, 2001.

<sup>68</sup> Frank Wolfe. "Navy to Submit Study on Incorporating Marine Corps Fixed-Air Wing." *Defense Daily*. September 4, 2001.

<sup>69</sup> Ricks, Thomas E. Navy Begins to Question New Attack Jet That Air Force and Marines Support. *Wall Street Journal*, September 9, 1997: A4; Bender, Bryan. Navy Says It's Fully Committed to Joint Strike Fighter. *Defense Daily*, September 12, 1997: 423-424.

<sup>70</sup> Castelli, Christopher. Air Force, Navy Directed to Fully Fund Joint Strike Fighter Program. *Inside the Air Force*. May 5, 2000.

Whitney or General Electric for the engine) will dominate U.S. defense industry to such an extent that competition will be seriously impaired.<sup>71</sup> These concerns are increased by the continuing consolidation of U.S. aircraft and defense companies, highlighted in 1997 by Boeing's acquisition of McDonnell Douglas and Lockheed Martin's proposed purchase of Northrop Grumman. Competition in weapons production is important not only because of cost-control implications but also for preservation of a broad base of technical skills and competing ideas. Lawrence Korb has warned that "the Pentagon's enthusiastic embrace of defense industry consolidation will ultimately leave it dependent on three giant companies that will have neither the incentive nor the capacity to come up with the technology breakthroughs that have been the foundation of U.S. military power."<sup>72</sup>

Others believe that there will still be enough work on combat aircraft programs to sustain a robust and competitive defense industrial base, arguing that firms not awarded prime contracts can still play important and profitable subcontractor roles in the JSF program as well as compete in other weapons programs.<sup>73</sup> In this view, production of the JSF could be shared by Boeing and Lockheed Martin, just as production of the F-22 is currently shared by these companies, which would preserve some degree of competitiveness in development and production of fighter aircraft although with additional budgetary cost.

To ensure that the "winner-take-all" strategy is in fact in the country's best interests, DoD acquisition chief Jacques Gansler empaneled a three-member committee to study the issue. On June 22, 2000 Under Secretary of Defense Gansler announced that for now, DoD would adhere to its original plan to award the JSF contract to a single company. In a letter to Rep. Jerry Lewis, Secretary of Defense William S. Cohen wrote "The Department has examined a number of options for continuing the JSF program once concept demonstration is completed. These options all assume the selection of a single, winning design. They range from winner-take-all to competition throughout production." Cohen also stated that DoD and the RAND Corp. would continue to examine these options so that the next Administration could make their own judgement on the strategy that most prudently addresses industrial base concerns. In a letter to the leadership for the Senate Armed Services Committee, Undersecretary of Defense for Acquisition Aldridge confirmed the Bush Administration's adherence to the winner take all strategy.

RAND released its study of DoD's "winner-take-all" strategy in April 2001 and endorsed this strategy. Their study found it unlikely that DoD would recoup costs through establishing a second production line, and suggested that the best way to keep costs down would be to give production to one team, and compete future

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<sup>71</sup> Aboulafia, Richard. From JAST to JSF — The Future of the Combat Aircraft Business, or More Doomed Paper Airplanes. *Military Technology*, May 1996: 84.

<sup>72</sup> Pearlstein, Steven. Boeing Free to Purchase McDonnell, *Washington Post*, July 2, 1997: A1.

<sup>73</sup> Fulghum, David A. and John D. Morocco. Final JSF Competition Offers No Sure Bets. *Aviation Week & Space Technology*, November 25, 1996: 20-22.

upgrades to the aircraft.<sup>74</sup> Aerospace experts are divided on the feasibility of pursuing RAND's approach.

The JSF program could also have a strong impact on the U.S. defense industry through export. Most observers believe that the JSF could dominate the combat aircraft export market much as the F-16 has. Some estimate that the potential export market for the JSF approaches 4,000 aircraft. Like the F-16, the JSF appears to be attractive due to 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.<sup>75</sup> Many competitors, 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-22 or the F/A-18E/F.

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.<sup>76</sup> 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.

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<sup>74</sup> Adam Hebert. "RAND: Funding Alternate JSF Avionics Teams Would Likely Benefit DoD." *Inside the Air Force*. April 6, 2001.

<sup>75</sup> Vago Muradian. "Coffman: JSF Critical to Preserving U.S. Leadership in World Fighter Market." *Defense Daily*. February 26, 2001.

<sup>76</sup> Aboulafia, Richard. Market Overviews — Commercial Jet Transports, Fighter/Attack Aircraft in *World Military and Civil Aircraft Briefing*. Teal Group Corp., February-March 1997.



## Appendix A: JSF Operational/Performance and Cost Requirements\*

Characteristics	USAF	USN	USMC
Range (nmi) <sup>a</sup>	450-600	600	450-550
Payload <sup>b</sup>	2000-lb AIM-120	2000-lb AIM-120	1000-lb AIM-120
Speed	subsonic cruise with supersonic dash speeds comparable to F-16 and F/A-18 <sup>c</sup>		
Affordability (FY94\$) <sup>d</sup>	\$31 M	\$31-38 M	\$30-35 M

\* Steidle, Craig E. The Joint Strike Fighter Program. *Johns Hopkins APL Technical Digest*, v. 18, January-March, 1997: 9. For more current USAF payload requirements, see Muradian, Vago. AF Seeks 2,000-Pound Weapons Capability in New JSF Requirement. *Defense Daily*, September 16, 1997: 445-447.

<sup>a</sup> Aircraft range is normally stated in nautical miles (nmi) of 6,080 ft, equivalent to 1.15 statute miles (mi) or 1.85 kilometers (km).

<sup>b</sup> Muradian, Vago. AF Seeks 2,000-Pound Weapons Capability in New JSF Requirement. *Defense Daily*, September 16, 1997: 445-447.

<sup>c</sup> The maximum dash speeds of these aircraft for short duration at high altitude with a clean configuration are reportedly Mach 2 for F-16s and Mach 1.8 for F/A-18s. Mach 1, the speed of sound, varies from 762 mph (662 nmph) at sealevel to 654 mph (576 nmph) at 35,000 ft. *Jane's All the World's Aircraft, 1996-97*: 649 and 657.

<sup>d</sup> These are the projected "flyaway costs" per aircraft in FY1994 dollars, which program officials have stated as affordability goals. As noted above on p. 4, flyaway cost represents a significant part of an aircraft's procurement cost but does not include the cost of all procurement items nor the costs of R&D and military construction.

## Appendix B: Pictures of JSF Variants

X-35A



X-35B



X-35C

