

March 2005

# TACTICAL AIRCRAFT

## Opportunity to Reduce Risks in the Joint Strike Fighter Program with Different Acquisition Strategy



G A O

Accountability \* Integrity \* Reliability



Highlights of [GAO-05-271](#), a report to Congressional Committees

## TACTICAL AIRCRAFT

# Opportunity to Reduce Risks in the Joint Strike Fighter Program with Different Acquisition Strategy

### Why GAO Did This Study

The Department of Defense's (DOD) Joint Strike Fighter (JSF) program aims to develop and field more than 2,400 stealthy fighter planes with greater capabilities than DOD's aging tactical aircraft. JSF is DOD's most costly aircraft program, with estimated life-cycle costs approaching \$600 billion.

Since the program began, in 1996, JSF has experienced significant cost and schedule overruns. While the program has worked to prepare more accurate cost and delivery estimates, upcoming investment decisions will indicate the level of risk DOD is willing to accept as the program moves forward and annual outlays significantly increase.

GAO is required by law to review the JSF program annually for the next 5 years. This first report analyzes JSF's business case for delivering new capabilities to the warfighter and determines whether JSF's current acquisition strategy follows best practices.

### What GAO Recommends

GAO recommends that DOD establish an executable program consistent with best practices and DOD policy regarding knowledge-based, evolutionary acquisitions. If DOD moves the program forward without capturing adequate knowledge, it should not make investments to increase production capability until it has. DOD partially concurred but believes its current practices achieve the recommendations' objectives.

[www.gao.gov/cgi-bin/getrpt?GAO-05-271](http://www.gao.gov/cgi-bin/getrpt?GAO-05-271).

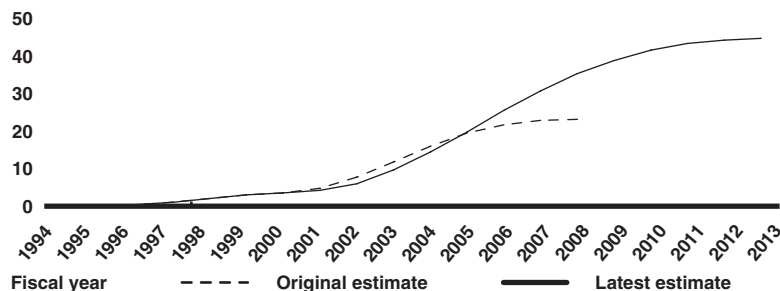
To view the full product, including the scope and methodology, click on the link above. For more information, contact Michael J. Sullivan at (202) 512-4841 or [sullivanm@gao.gov](mailto:sullivanm@gao.gov).

### What GAO Found

Several program changes have made the original JSF business case unexecutable. Since initial estimates in 1996, development costs have grown over 80 percent, or \$20 billion. Program acquisition unit costs have increased by 23 percent, or \$19 million, since 2001. In addition, delivery of the first JSFs to the warfighter has been delayed 2 years so far. Continued program uncertainties make it difficult to estimate the resources needed for the program. For example, the full impact of recent aircraft design changes on the program may not be fully understood for some time, and the Navy, Air Force, and Marines—the program's primary customers—have not determined the number of aircraft they expect to buy. Given the uncertainties, the program could use more time to gain knowledge before moving forward. DOD will also be challenged to deliver on future business case agreements if program accountability continues to be compromised by frequent changes in program management.

#### Original and Latest Development Cost Estimates

Dollars in billions



Source: GAO analysis of DOD data.

The program's current acquisition strategy does not follow a knowledge-based, evolutionary approach as dictated by best practices and DOD policy. Such a strategy is key to successfully executing a new JSF business case. However, JSF preliminary plans call for the developer to manufacture about 20 percent of the JSF fleet in the low-rate initial production phase—at a cost of about \$50 billion—while still developing JSF technologies and integrating and demonstrating the product design, making cost and schedule increases likely. To achieve low-rate production capacity, DOD will need to invest in personnel, facilities, and tooling—increasing its production investment from \$100 million a month in 2007 to \$1 billion a month in 2013—before flight testing is completed. Problems discovered late in flight tests could result in further cost increases and delivery delays, as well as reduced quality and reliability. To execute its strategy, the JSF program will need to compete with other large programs for scarce funding, which could be a significant challenge because JSF's funding profile assumes an unprecedented \$225 billion over the next 2 decades—an average of \$10 billion a year. Finally, the strategy assumes the use of a cost reimbursement contract for initial production, placing a high burden of risk on the government, given the large number of aircraft.

---

# Contents

---

<b>Letter</b>		<b>1</b>
	Results in Brief	2
	Background	4
	More Resources Are Now Needed to Deliver Planned Capabilities	6
	JSF's Current Acquisition Strategy May Not Provide for Successful Program Execution	14
	Conclusions	24
	Recommendations for Executive Actions	25
	Agency Comments and Our Evaluation	26
<b>Appendix I</b>	<b>Comments from the Department of Defense</b>	<b>30</b>
<b>Appendix II</b>	<b>Scope and Methodology</b>	<b>34</b>
<b>Appendix III</b>	<b>Projected Time Frames for Demonstration of Critical Technologies</b>	<b>36</b>
<b>Appendix IV</b>	<b>Measures of JSF Program Cost and Schedule Changes</b>	<b>38</b>
<b>Tables</b>		
	Table 1: Military Services' Planned Use for the Joint Strike Fighter	5
	Table 2: Changes in JSF Program Purchase Quantities, Costs, and Delivery Estimates	7
	Table 3: Changes in Unit Flyaway Cost for JSF Variants	10
	Table 4: Knowledge Attainment on JSF Program at Critical Junctures	17
<b>Figures</b>		
	Figure 1: Development Costs	9
	Figure 2: Changes to the Program Schedule	11
	Figure 3: JSF Acquisition Approach Compared with Best Practices Approach for an Evolutionary, Knowledge-Based Acquisition Process	15

---

Figure 4: Overlap of JSF Low-Rate Production and System Development and Demonstration Activities	21
Figure 5: JSF Program's Annual Funding Requirements	23

---

### Abbreviations

DOD	Department of Defense
JSF	Joint Strike Fighter
OSD	Office of the Secretary of Defense

This is a work of the U.S. government and is not subject to copyright protection in the United States. It may be reproduced and distributed in its entirety without further permission from GAO. However, because this work may contain copyrighted images or other material, permission from the copyright holder may be necessary if you wish to reproduce this material separately.



United States Government Accountability Office  
Washington, DC 20548

---

March 15, 2005

Congressional Committees

The Joint Strike Fighter (JSF) program is the Department of Defense's (DOD) most costly aircraft acquisition. The program's goals are to develop and field more than 2,400 stealthy strike fighter aircraft for the Navy, Air Force, and Marine Corps and potentially several hundred more aircraft for U.S. allies. The JSF is intended to provide greater capability and to replace DOD's aging fighter and attack aircraft. DOD estimates that the total cost to develop and procure its fleet of aircraft will reach \$245 billion, with total costs to maintain and operate the JSF adding another \$344 billion over its life cycle. This expense must be measured against other DOD and national priorities as the government moves into lean budget years. The JSF will be competing for a decreasing share of the federal budget available for "discretionary" spending. This includes defense spending and is in contrast to "mandatory" spending, such as Social Security and Medicare/Medicaid. In fiscal year 2004, discretionary spending accounted for about 39 percent of the federal budget. The Congressional Budget Office projects that discretionary spending, as a percentage of the overall budget, is likely to decrease in the future.<sup>1</sup>

Since the program began, in November 1996, it has experienced technical challenges that have resulted in significant cost increases and schedule overruns. During most of 2004, program officials worked to understand and define current development risks in order to prepare more accurate cost and delivery estimates. The upcoming investment decisions to begin manufacturing development prototypes and to begin long-lead funding for production aircraft in 2006 will be prominent indicators of the risk DOD is willing to accept as the JSF program moves forward and annual outlays needed to support the program significantly increase.

The Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 (P.L. 108-375) requires us to review the JSF program annually for the

---

<sup>1</sup>Congressional Budget Office, *The Budget and Economic Outlook: An Update*. (Washington, DC: September 2004).

---

next 5 years.<sup>2</sup> This is our first report, and it (1) analyzes the JSF program's business case<sup>3</sup> for delivering new capabilities to the warfighter and (2) determines whether the JSF program's acquisition strategy follows an evolutionary, knowledge-based approach. The best practice is to establish an incremental—or evolutionary—approach to meet these needs by delivering increasingly better performance over time as funding and technologies permit and provide specific knowledge about the system at key decision points in the acquisition process.

The act also requires us to certify whether we had access to sufficient information to make informed judgments on the matters contained in our report. As a result of a lengthy program replanning effort that had been in process during most of 2004, we did not have access to the cost estimate expected to be contained in JSF's Selected Acquisition Report, to be delivered to Congress in the spring of 2005. At the time of our review, JSF program officials were still collecting the necessary information to develop and complete this estimate. Therefore, our review was limited to the estimated program costs contained in the December 31, 2003, Selected Acquisition Report. We did, however, have access to top-level program and preliminary schedule information reflecting the status of the replanning effort. Recognizing this limitation in scope, we did have access to sufficient information to make informed judgments on the matters covered in this report. We performed our work from June 2004 through March 2005 in accordance with generally accepted government auditing standards. For more on our scope and methodology, see appendix II.

---

## Results in Brief

The original business case for the JSF program has proven to be unexecutable. DOD now plans to buy 535 fewer aircraft than originally planned. Development costs have grown over 80 percent, from \$25 billion to \$45 billion, since the program started in 1996. Total program costs have increased by 5 percent, or \$12 billion, and program acquisition unit costs have increased by 23 percent, or \$19 million, since first estimates in 2001.

---

<sup>2</sup>Section 213 of the act requires us to assess the extent to which the system development and demonstration program is currently meeting key cost, schedule, and performance goals; the likelihood that the program will be completed within estimated costs; and the program's current acquisition plan leading to production.

<sup>3</sup>The business case is demonstrated evidence that (1) the warfighter need exists and that it can best be met with the chosen concept, and (2) the concept can be developed and produced within existing resources—including design knowledge, demonstrated technologies, adequate funding, and adequate time to deliver the product.

---

This has resulted in a reduction in buying power in that DOD is now buying fewer JSFs at a higher investment than originally planned. The first delivery of initial operational capabilities to the warfighter has been delayed 2 years so far. DOD may not know for some time what the program will cost or when it will be able to deliver needed capabilities. The program is still redesigning the three variants of the aircraft that it plans to deliver and is examining the software development and flight test programs. The services—the program’s customers—have not determined the exact quantities of each variant they expect to buy. Finally, DOD’s past practice of changing JSF program managers approximately every 2 years decreases accountability and, if continued, will make it more difficult to deliver on future business case agreements.

The program’s current acquisition strategy does not fully follow the intent of DOD’s evolutionary, knowledge-based acquisition policy that is based on best practices. An evolutionary, knowledge-based strategy will be necessary to successfully execute a new business case in the future. Instead, the program plans to concurrently develop the JSF technologies, integrate and demonstrate the expected product design, and produce deliverable fighters—a risky approach. JSF’s acquisition strategy is to have the developer manufacture nearly 20 percent of the planned JSF fleet at a cost of approximately \$50 billion beginning in 2007, well before system development and demonstration is expected to be completed in 2013. To achieve planned low-rate initial production capacity, DOD must make significant investments in tooling, facilities, and personnel. Once the production decision is made, DOD’s planned investment for production will increase from \$100 million a month in 2007 to about \$1 billion a month before testing is completed in 2013. Because this substantial investment in procurement will take place while the program is still designing and testing the development aircraft, it increases the likelihood of costly design changes to production aircraft and manufacturing processes, reduced quality and reliability, and further delays in the delivery of JSFs to the warfighter. Moreover, the program acquisition strategy assumes an unprecedented \$225 billion in acquisition funding over the next 22 years, or an average of \$10 billion a year. As a result, the JSF program will need to successfully compete with many other large programs for scarce funding during this same time frame. Finally, the strategy assumes the use of a cost reimbursement-type contract for initial production, placing a high risk burden on the government during the early production phase.

We are recommending that DOD establish an executable program consistent with best practices and DOD policy regarding evolutionary acquisitions. DOD officials should define an affordable first increment,

---

with its own business case, that clearly defines the warfighters' most immediate needs and accurately identifies the resources required to deliver on this needed capability. We are also recommending DOD develop and implement a knowledge-based acquisition approach, as called for by best practices and DOD's acquisition policy, an approach that ensures attainment and use of demonstrated product knowledge before making future investments for each product increment. Before increasing the investment in production resources (tooling, materials, and personnel) greater than that already in place to support the manufacturing of development test aircraft, the Secretary of Defense should ensure knowledge consistent with best practices is captured.

DOD partially concurred with our recommendations, stating that the department is confident management practices and processes currently in place achieve the objective of our recommendations. It also stated that the JSF acquisition strategy and execution activities ensure the department commits resources only after determining that specific developmental or knowledge-based criteria are achieved. We continue to believe that our recommendations would reduce risks and save time and money over the life of the program through a more rigorous and comprehensive application of an evolutionary, knowledge-based process, a process anchored with high standards for capturing knowledge at critical junctures and used for making investment decisions in the future.

---

## Background

JSF is a joint, multinational acquisition program for the Air Force, Navy, Marine Corps, and eight cooperative international partners. The program began in November 1996 with a 5-year competition between Lockheed Martin and Boeing to determine the most capable and affordable preliminary aircraft design. Lockheed Martin won the competition, and the program entered system development and demonstration in October 2001.

The program's objective is to develop and deploy a technically superior and affordable fleet of aircraft that support the warfighter in performing a wide range of missions in a variety of theaters. The single-seat, single-engine aircraft is being designed to be self-sufficient or part of a multisystem and multiservice operation, and to rapidly transition between air-to-surface and air-to-air missions while still airborne. To achieve its mission, the JSF will incorporate low observable technologies, defensive



avionics, advanced onboard and offboard sensor fusion,<sup>4</sup> and internal and external weapons. The JSF aircraft design has three variants: conventional takeoff and landing variant for the Air Force, aircraft carrier-suitable variant for the Navy, and short takeoff and vertical landing variant for the Marine Corps, the United Kingdom, and the Air Force. These aircraft are intended to replace aging fighter and attack aircraft currently in the inventory (see table 1).

**Table 1: Military Services' Planned Use for the Joint Strike Fighter**

Service	Planned use
Air Force	Replacement for the F-16 and A-10; complement the F/A-22
Marine Corps	Replacement for the AV-8B and F/A-18 A/C/D
Navy	Complement the F/A-18 E/F
United Kingdom	Replacement for the Sea Harrier and GR-7

Source: DOD data.

In 2004, DOD extended the JSF program schedule to address problems discovered during systems integration and the preliminary design review. Design efforts revealed significant airframe weight problems that affected the aircraft's ability to meet key performance requirements. Software development and integration also posed a significant development challenge. Program officials delayed the critical design reviews, first flights of development aircraft, and the low-rate initial production decision to allow more time to mitigate design risk and gather more knowledge before continuing to make major investments. As a result, the initial operational capability date was delayed. DOD is in the process of reestablishing resource levels needed to deliver capabilities, given current and expected future conditions. The new business case will be presented to the Office of the Secretary of Defense (OSD) decision makers this spring.

A key to successful product development is the formulation of a business case that matches requirements with resources—proven technologies, sufficient engineering capabilities, time, and funding—when undertaking a new product development. First, the user's needs must be accurately

<sup>4</sup>Sensor fusion is the ability to take information from both multiple onboard and offboard aircraft sensors and display the information in an easy-to-use format for the pilot. This is vitally important, since the JSF is a single-seat aircraft, and the pilot needs help to carry out multiple types of missions.

---

defined, alternative approaches to satisfying these needs properly analyzed, and quantities needed for the chosen system must be well understood. The developed product must be producible at a cost that matches the users' expectations and budgetary resources. Finally, the developer must have the resources to design and deliver the product with the features that the customer wants and to deliver it when it is needed. If the financial, material, and intellectual resources to develop the product are not available, development does not go forward. If the business case measures up, the organization commits to the development of the product, including the financial investment. This calls for a realistic assessment of risks and costs; doing otherwise undermines the intent of the business case and invites failure. Program managers in organizations employing best practices are incentivized to identify risk early, be intolerant of unknowns, and be conservative in their estimates. Ultimately, preserving the business case strengthens the ability of managers to say no to pressures to accept high risks or unknowns.

---

## More Resources Are Now Needed to Deliver Planned Capabilities

A key objective of the JSF acquisition program is to develop and produce fighter aircraft with greater capabilities and lower acquisition and ownership costs than previous fighter aircraft and to deliver the aircraft in time to replace DOD's aging fleet. However, since the program began in 1996, several program decisions have resulted in increased program costs, reduced procurement quantities, and delayed delivery dates—making the original business case unexecutable. Continued program uncertainties about the aircraft redesign, software development, flight test program, and procurement quantities make it difficult to estimate the total amount of resources needed. Given the uncertainties, the program needs more time to gain knowledge before committing to a new, more accurate business case. The current pause to replan JSF development and production provides the program this opportunity. Finally, frequent changes in JSF program management, if continued, will compromise efforts to execute the business case agreements.

---

## JSF's Original Business Case Is Unexecutable

Several significant changes to the JSF acquisition program have made DOD's original business case unexecutable. Purchase quantities have been reduced by more than 500 aircraft, total program costs have increased by about \$12 billion, and delivery of the aircraft has been delayed by about 2 years (see table 2 and app. IV for more details). These changes have effectively reduced DOD's buying power for its investment, as it now plans to buy fewer aircraft with a greater financial investment.

**Table 2: Changes in JSF Program Purchase Quantities, Costs, and Delivery Estimates**

	November 1996 (program start)	October 2001 (system development start)	As of January 2005
<b>Expected quantities</b>			
Development quantities	10	14	15
Procurement quantities (U.S. only)	2,978	2,852	2,443
Total quantities	2,988	2,866	2,458
<b>Cost estimates</b> (then year dollars in billions)			
Development	\$24.8	\$34.4	\$44.8
Procurement	Not available	\$196.6	\$199.8
Other	Not available	\$2.0	\$0.2
Total program	Not available	\$233.0	\$244.8
<b>Unit cost estimates</b> (then year dollars in millions)			
Program acquisition	Not available	\$81	\$100
Total ownership	Not available	\$217	\$240
<b>Estimated delivery dates</b>			
First aircraft delivery	2007	2008	2009
Initial operational capability	2010	2010-2012	2012-2013

Source: GAO analysis of DOD data.

**Reduced Quantities and Increased Costs Have Lessened the JSF Program’s Buying Power**

The JSF acquisition program’s estimated development and procurement costs have increased. In addition, the number of aircraft it plans to deliver has been reduced. As a result, unit costs for the JSF aircraft have increased substantially, thereby reducing the program’s buying power. The most significant quantity reduction occurred after system development began in 2001, when the program reduced the number of aircraft it plans to procure from 2,852 to 2,443, or by 14 percent. The Navy—concerned that it could not afford the number of tactical aircraft it planned to purchase—reduced the number of JSF aircraft for joint Navy and Marine Corps operations from 1,089 to 680 by reducing the number of backup aircraft needed. However, the Navy has not indicated to the developer the exact mix of the carrier and short takeoff and vertical landing variants it intends to purchase.

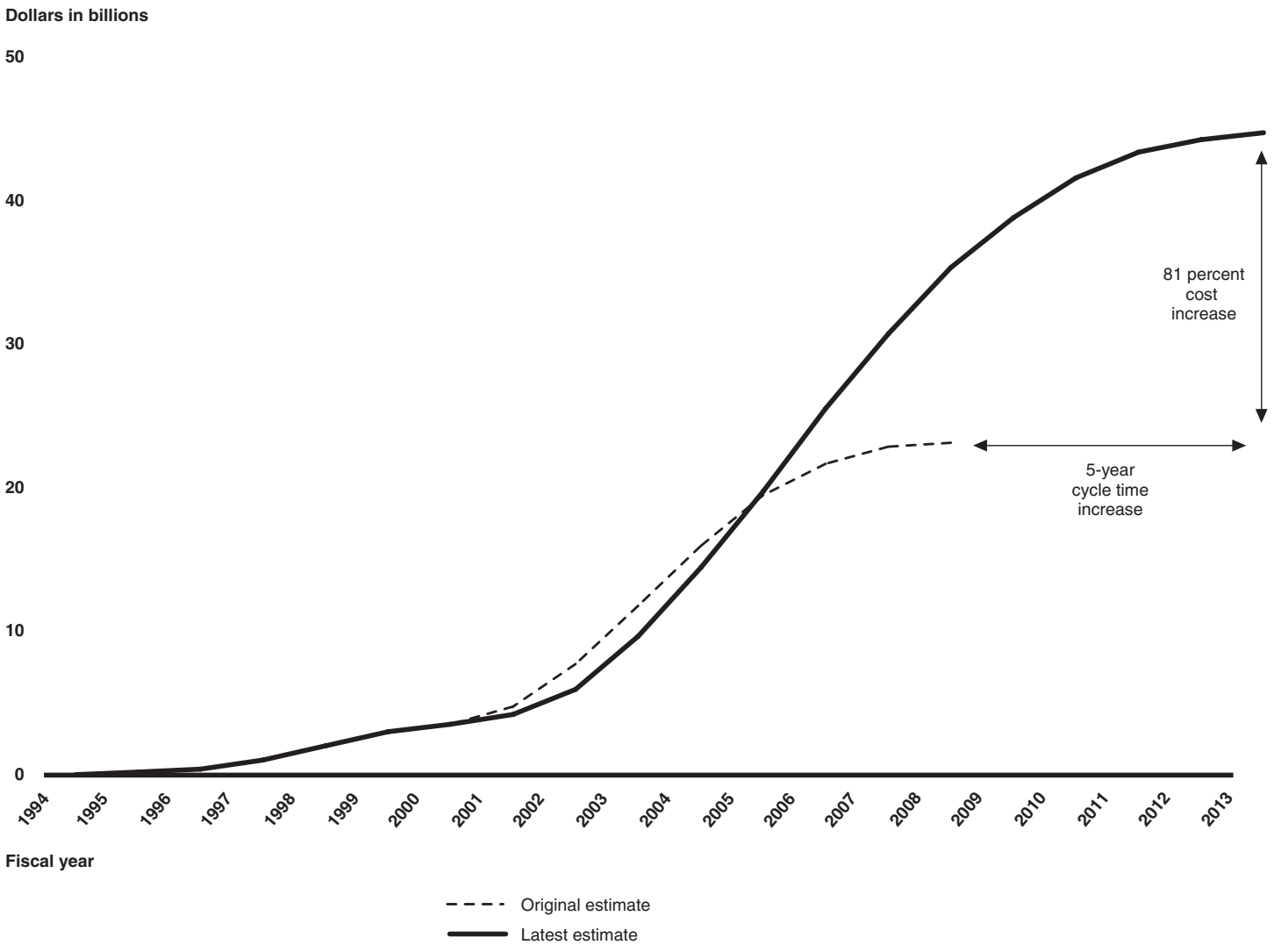
The cost estimate to fully develop the JSF has increased by over 80 percent. DOD expected that by using a joint development program for the three variants instead of three separate programs, JSF development costs could be cut by about 40 percent. However, cost increases have nearly eroded all of the estimated savings. Development costs were originally estimated at \$24.8 billion. By the 2001 system development decision, these

---

costs had increased by \$9.6 billion largely because of a 36-month schedule extension to allow more time to mature the mission systems and a more mature cost estimate.

By 2004, costs increased an additional \$10.4 billion to \$44.8 billion. The program office cited several reasons, including efforts to achieve greater international commonality, optimize engine interchangeability, refine the estimating methodology, and extend the schedule for unexpected design work. Almost half of this increase, \$4.9 billion, was a result of an approximately 18-month delay for unexpected design work caused by increased aircraft weight that degraded the aircraft's key performance capabilities. Figure 1 compares the original and latest development cost estimates.

**Figure 1: Development Costs**



Current estimates for the program acquisition unit cost are about \$100 million, and the total estimated cost to own an aircraft over its life cycle is \$240 million—an increase of 23 percent and 11 percent, respectively. In

1996, the program established unit flyaway cost<sup>5</sup> goals for each variant, expecting the variants to have a high degree of commonality and to be built on a common production line. However, commonality among the variants has decreased, and the cost to produce the aircraft has increased (see table 3). The unit flyaway cost for the conventional takeoff and landing variant has increased by 42 percent; the cost for the short takeoff and vertical landing variant has increased by a range of 37 to 55 percent; and the cost for the carrier variant has increased by a range of 29 to 43 percent. According to program data, a large part of the cost increase since the start of development can be attributed to labor costs for building the airframe and to the costs for producing the complex mission systems.

**Table 3: Changes in Unit Flyaway Cost for JSF Variants**

Variant (Unit flyaway costs are stated in millions of fiscal year 2002 dollars)	November 1996 (program start)	October 2001 (system development start)	As of January 2005
Conventional takeoff and landing	\$31.5	\$37.0	\$44.8
Short takeoff and vertical landing	\$33.7-39.3	\$45.8	\$54.0-61.1
Carrier	\$34.9-42.7	\$47.8	\$55.0-61.0

Source: DOD data.

With reduced quantities and increased program costs, the JSF program is now buying fewer aircraft at a higher cost, thereby reducing the program's buying power. How effectively DOD manages its JSF funds will determine whether it receives a good return on its investment. A sound and executable business case is needed to effectively do this. Our reviews over the past 20 years have consistently found that DOD's weapon system acquisitions take much longer and cost more than originally planned, causing disruptions and increasing pressures to make unplanned trade-offs to accommodate the resulting budget needs.

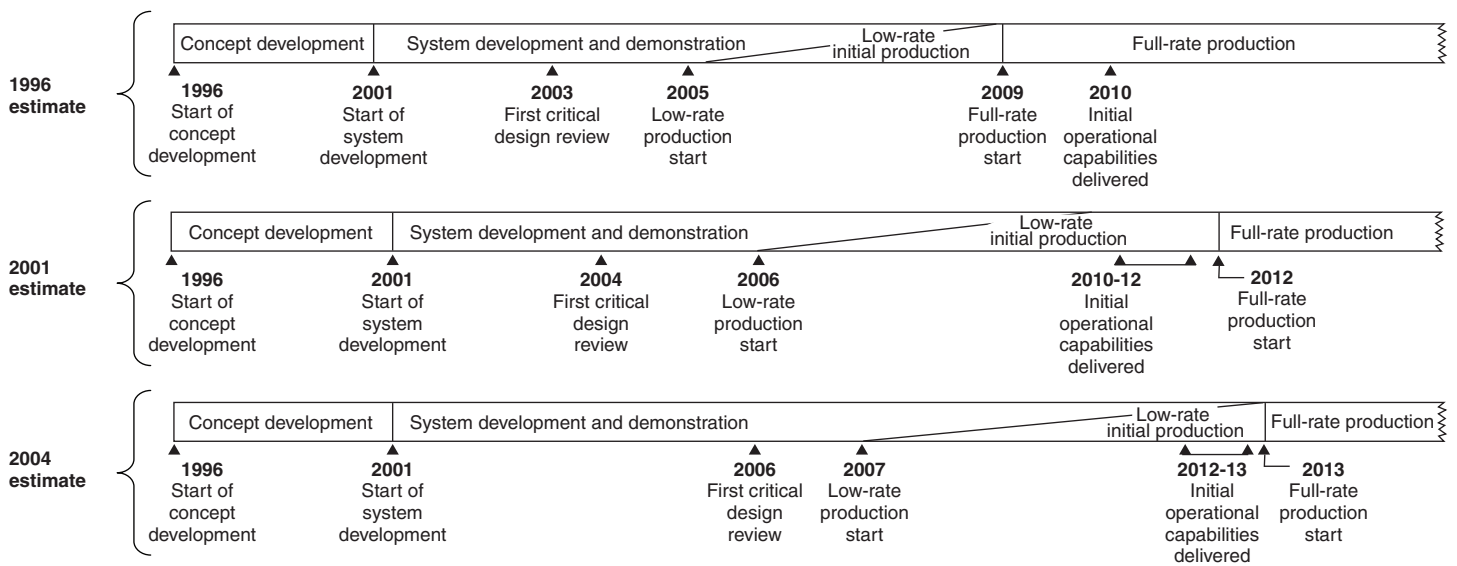
### Operational Capabilities Have Been Delayed

The timely delivery of the JSF to replace aging legacy aircraft was cited as a critical need by the warfighter at the program start. When the program was initiated, in 1996, it planned to deliver initial operational capabilities to the warfighter in 2010. However, largely because of technical challenges, the program has delayed the delivery of operational aircraft, and current estimates put delivery at 2012 to 2013. Because of these

<sup>5</sup>Unit flyaway costs include the recurring costs to produce the basic aircraft, propulsion system, and mission systems. Unit flyaway costs are stated in fiscal year 2002 dollars.

delays, the services may have to operate legacy aircraft longer than expected. These challenges have also delayed interim milestones such as the start of system development, design reviews, and production decisions. Figure 2 illustrates changes to the overall program schedule since it began in 1996 through 2004.

**Figure 2: Changes to the Program Schedule (1996 through 2004)**



Source: GAO analysis of DOD data.

## Program Uncertainties Make It Difficult to Estimate Resources

The full impact on costs, schedules, and aircraft performance brought about by recent design changes and aggressive software development and flight test programs add risks that may not be fully understood for some time. Continuing uncertainties about total quantities and types of the three JSF variants that the services and the international partners expect to purchase in the future also make it difficult to accurately estimate costs and schedules.

## Aircraft Design, Software Development, and Flight Test Program Not Fully Understood

In December 2003, DOD estimated program costs based on a notional idea of a restructured program. The cost estimates not only lacked detail but were based on a different aircraft design, development schedule, and procurement plan than what is now being considered. Over the past year, DOD has been working to restructure the JSF program to accommodate changes in the aircraft's design; until this restructuring is completed, it will be difficult to accurately estimate program costs. The need for design

---

changes largely resulted from the increased weight of the short takeoff and vertical landing variant and the impact it was having on key performance parameters. The other JSF variants' designs were affected as well. The program plans to have a more comprehensive cost estimate in the spring of 2005. However, a detailed assessment has not been conducted to determine the exact impact that the restructured program will have on meeting performance specifications. Until the detailed design efforts are complete—after the critical design review in February 2006—the program will have difficulty assessing the impact of the design changes on performance. While the program office anticipates that recent design changes will allow the aircraft to meet key performance parameters, preliminary program data indicate that the design is still not meeting several speed, maneuverability, and radar cross section specifications.<sup>6</sup> In addition, program officials noted that they will not know with certainty if the weight problems have been resolved until after the plane is manufactured and weighed in mid-2007.

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

#### Quantities of Variants Still Unknown

Continued uncertainty about the number and mix of variants the services plan to purchase also affects JSF's acquisition plans. While the Air Force has announced its intention to acquire the short takeoff and vertical landing variant, it has yet to announce when or how many it expects to buy or how this purchase will affect the quantity of the conventional

---

<sup>6</sup>Prior to these changes, the program was not meeting about 25 percent of the contract performance specifications.



---

takeoff and landing variant it plans to buy.<sup>7</sup> DOD's 2003 acquisition report states that the annual total quantity and mix of JSF variants and their related procurement costs for Navy and Marine Corps JSF purchases remains to be determined. Foreign partners have expressed intent to buy about 700 aircraft between 2012 and 2015, but no formal agreements have been signed at this time.

The upcoming 2005 Quadrennial Defense Review—an examination of U.S. defense needs conducted every 4 years—could also affect the procurement quantities and schedule.

---

### Frequently Changing Program Managers Reduces Accountability

Since the JSF program began, a little over 8 years ago, the program has had five program managers—a new program manager assigned about every 2 years. The development program is estimated to last another 9 years, and it is likely that the program manager currently involved in decisions about key program elements such as design, cost, and schedule will not be responsible for seeing JSF through its completion. In other words, plans accepted now will likely become the responsibility of future program managers.

Leading commercial firms limit product development cycle times, thereby increasing the possibility that program managers will remain on programs until they are complete. Holding one program manager accountable for the content of the program when key decisions are made encourages that person to raise issues and problems early and realistically estimate the resources needed to deliver the program. This puts the manager in a good position to deliver a high-quality product on time and within budget. We note that the law governing the defense acquisition workforce recognizes the need for long-term assignments in the performance of the program manager function.<sup>8</sup> Specifically, the assignment period for program managers is required to be at least until completion of the major milestone that occurs closest in time to the date on which the manager has served in the position for 4 years.

---

<sup>7</sup>In December 2004, Air Combat Command officials told us that the Air Force is considering buying about 250 short takeoff and landing JSFs and about 1,300 conventional takeoff and landing JSFs. However, these numbers are not official.

<sup>8</sup>10 U.S.C. section 1734 states this required assignment period can be waived “in exceptional circumstances.”

---

## JSF's Current Acquisition Strategy May Not Provide for Successful Program Execution

The JSF program does not have an evolutionary, knowledge-based acquisition strategy that fully follows the intent of DOD's acquisition policy. This type of strategy is necessary for having an executable business case in the future. The current strategy includes plans to make large production commitments well before system development and testing have been completed, significantly increasing the risk of further delays and cost increases due to design changes and manufacturing inefficiencies. It is also dependent on an aggressive test aircraft delivery schedule and an optimistic funding profile that assumes an unprecedented \$225 billion over the next 22 years, or an average of \$10 billion a year. DOD plans to bear the financial risk of concurrently developing and initially producing the JSF on a cost reimbursement basis with the prime contractor, an uncommon practice for such a large number of units, until the design and manufacturing processes are mature. Program officials currently have an opportunity to change the acquisition strategy. DOD policy and best practices call for programs to use an acquisition strategy that reflects an evolutionary, knowledge-based approach—that is, one that ensures appropriate technology, design, and manufacturing knowledge are captured at key milestones before committing to increased investments. Our past work has shown that when programs demonstrate a high level of knowledge before making significant commitments, they are able to deliver products within identified resources.

---

## JSF Program Not Fully Employing an Evolutionary, Knowledge-Based Approach

In recent years, DOD has revised its acquisition policy to support an evolutionary, knowledge-based approach for acquiring major weapon systems based on best practices.<sup>9</sup> JSF's acquisition strategy does not fully follow the intent of this policy. Instead, it strives to achieve the ultimate JSF capability within a single product development increment. While the acquisition strategy calls for delivering a small number of aircraft with limited capabilities, the program has committed to deliver the full capability by the end of system development and demonstration in 2013 within an established cost and schedule, contrary to an evolutionary approach. The JSF program bypassed early opportunities to trade or defer to later increments those features and capabilities that could not be

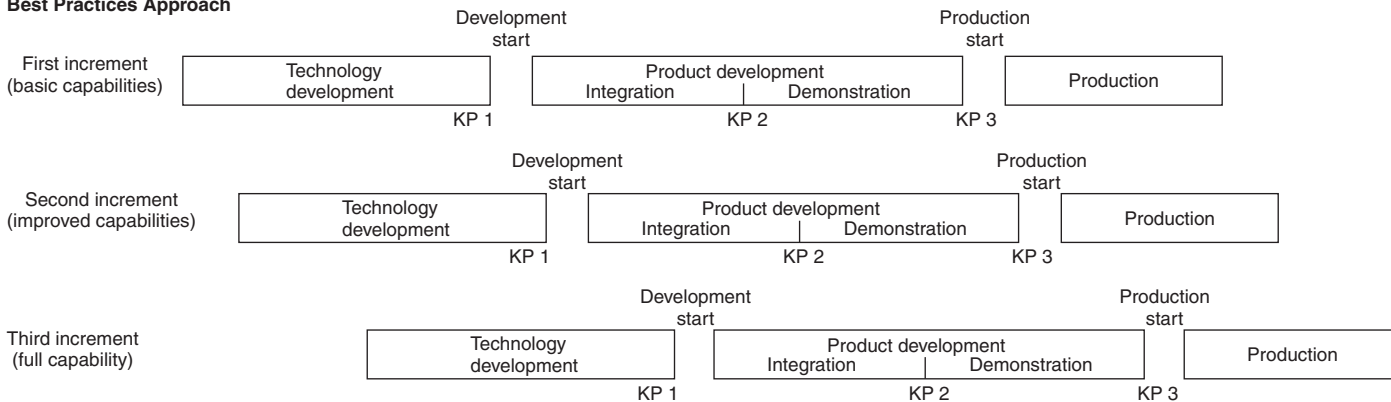
---

<sup>9</sup>DOD Directive 5000.1, *The Defense Acquisition System* (May 2003); DOD Instruction 5000.2, *Operation of the Defense Acquisition System* (May 2003). The directive establishes evolutionary acquisition strategies as the preferred approach to satisfying DOD's operational needs. The directive also requires program managers to provide knowledge about key aspects of a system at key points in the acquisition process. The instruction implements the directive and establishes detailed policy for evolutionary acquisition.

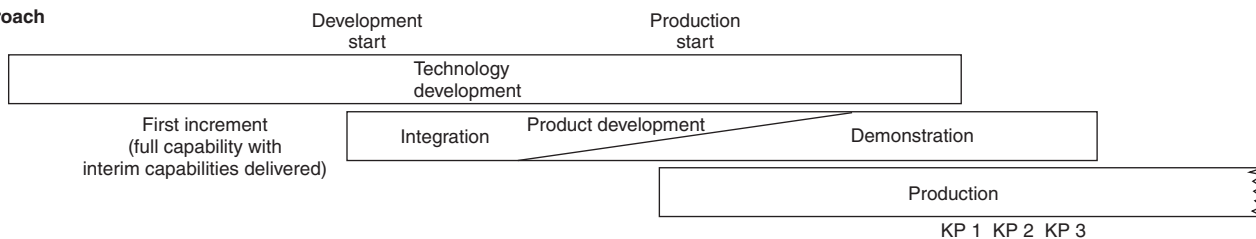
readily met. The planned approach will not capture adequate knowledge about technologies, design, and manufacturing processes for investment decisions at key investment junctures. Figure 3 shows a comparison of an evolutionary, knowledge-based process based on best practices and JSF's more concurrent approach.

**Figure 3: JSF Acquisition Approach Compared with Best Practices Approach for an Evolutionary, Knowledge-Based Acquisition Process**

**Best Practices Approach**



**JSF Program Approach**



KP 1 (knowledge point 1): technologies and resources match requirements  
 KP 2 (knowledge point 2): design performs as expected  
 KP 3 (knowledge point 3): production can meet cost, schedule, and quality targets

Source: GAO analysis of DOD data.

Successful commercial companies use an evolutionary acquisition approach where new products are developed in increments based on available resources. Companies have found that trying to capture the knowledge required to stabilize the design of a product that requires significant amounts of new content is an unmanageable task if the goal is to reduce cycle times and get the product to the customer as quickly as possible. With an evolutionary acquisition approach, design elements that are not currently achievable are planned for and managed as increments in

---

future generations of the product, and each increment is managed as a separate knowledge-based acquisition, with separate milestones, costs, and schedules.

Programs that attain the right knowledge at the right time reduce the risk of incurring design, development, and manufacturing problems that result in cost and schedule overruns. Our past work has shown that to ensure successful program outcomes, a high level of demonstrated knowledge must be attained at three key junctures for each increment in the program.

- At knowledge point 1, the customer’s needs should match the developer’s available resources—mature technologies, engineering knowledge, time, and funding—before system development starts. This is indicated by a demonstration that technologies needed to meet essential product requirements work in their intended environment and the producer has completed a preliminary design of the product that shows that the design is feasible.
- At knowledge point 2, the product’s design is stable and has demonstrated that it is capable of meeting performance requirements before transitioning from system integration to system demonstration. This is best indicated by a prototype demonstration of the design and release of 90 percent of the engineering drawings to manufacturing organizations.
- At knowledge point 3, the product must be producible within cost, schedule, and quality targets and demonstrated to be reliable and work as intended before production begins. This is indicated by a demonstration of an integrated product in its intended environment and by bringing critical manufacturing processes under statistical control.

### JSF Began System Development Well before Knowledge Point 1

The start of the JSF system development was approved in 2001—well before a match was made between the customer’s requirements and the resources needed to meet those requirements. Many of the technologies needed for the product’s full capabilities were demonstrated only in a lab environment or ground testing and not in the form, fit, or functionality needed for the intended product design. Also, while the program had a proposed technical solution to meet the warfighter’s requirements, it did not deliver a preliminary design based on sound systems engineering principles. At the JSF preliminary design review, held about 1½ years after development started, significant design issues surfaced, potentially affecting the critical performance capabilities of the aircraft. The program has worked to find solutions to design problems, but at a substantial cost. The detailed design work has fallen behind schedule, delaying the critical design reviews for 16 to 22 months. Table 4 compares the product

knowledge available at the JSF system development start and the knowledge expected to be available to support future decision points based on the current acquisition plan.

**Table 4: Knowledge Attainment on JSF Program at Critical Junctures**

Decision points	Development start—2001	Design review—2006	Production start—2007
<b>Investment decision</b>	<p><b>Develop a product that meets customer expectations within available resources.</b></p> <p>Requires a significant financial commitment to design, integrate, and demonstrate that the product will meet the user’s requirements and can be manufactured on time, with high quality, and at cost that provides an acceptable return on investment.</p>	<p><b>Transition from system integration to system demonstration.</b></p> <p>Requires significant investment to start building and testing production representative prototypes in a manufacturing environment.</p>	<p><b>Produce and deliver a product to the user.</b></p> <p>Requires significant investments for materials and resources such as additional tooling to build the product at planned rates, facilities, personnel, training, and support.</p>
<b>Best practice</b>	<p><b>Attain knowledge point 1.</b></p> <p>Separate technology and product development, deliver mature technology, and have preliminary design based on systems engineering principles.</p>	<p><b>Attain knowledge point 2.</b></p> <p>Completion of 90 percent of engineering drawing packages for structures and systems, critical design review completed, and design prototyped.</p>	<p><b>Attain knowledge point 3.</b></p> <p>One hundred percent of critical manufacturing processes under statistical control, demonstration of a fully integrated product in its operational environment to show it will work as intended, and reliability goals demonstrated.</p>
<b>JSF practice</b>	<p><b>Knowledge point 1 was not attained.</b></p> <p>Failed to separate technology and product development. Critical technologies not mature and sound preliminary design not established. Several technologies not expected to be mature until after production begins.</p>	<p><b>Knowledge point 2 will not be attained under current plan.</b></p> <p>The program estimates 35 percent of the engineering drawing packages are expected to be released at the critical design review. Also, prototype testing will not be done prior to the design review. The design will not be stable until after production begins.</p>	<p><b>Knowledge point 3 will not be attained under current plan.</b></p> <p>The program does not expect to demonstrate that the critical processes are under statistical control until 2009. The program expects to demonstrate that a fully integrated aircraft will work as intended and meets reliability goals in 2010-2012 time frame.</p>

Source: GAO data and analysis of DOD data.

**JSF Program Plans to Commit Significant Resources to System Demonstration before Reaching Knowledge Point 2**

Knowing that a product’s design is stable before system demonstration reduces the risk of costly design changes occurring during the manufacturing of production representative prototypes—when investments in acquisitions become even more significant. The JSF program expects to have all critical drawings and a small number of other drawings completed by the planned February 2006 critical design review—

---

the milestone at which design stability is determined.<sup>10</sup> However, these drawings represent only about 35 percent of the total drawings needed to complete the JSF design. While program officials believe that having 35 percent of the total drawings will allow them to track JSF's design stability, we have found that programs that moved forward with less than 90 percent of the total drawings at the start of the product demonstration phase were challenged to stabilize the design at the same time they were trying to build and test the product. This overlap frequently results in costly design changes and parts shortages during manufacturing, which, in turn, result in labor inefficiencies, schedule delays, and quality problems.<sup>11</sup> The F/A-22 and PAC-3 missile are prime examples of programs that failed to complete 90 percent of their drawings by the critical design review and suffered substantial cost increases and schedule delays.

Using prototypes to demonstrate the design is a best practice that provides additional evidence of design stability. JSF will not have this type of demonstration before the critical design review. Prototype testing allows the design to be demonstrated before making costly investments in materials, manufacturing equipment, and personnel to begin building production representative prototypes for the system demonstration phase. The JSF program is building an early prototype of the conventional takeoff and landing variant and plans to use this prototype to validate performance predictions, manufacturing processes, and reliability and maintainability models.<sup>12</sup> According to the current schedule, however, the first demonstrations will occur after the critical design review, after most of the design drawings have been released, and after manufacturing has begun for many of the remaining test aircraft. Any significant design problems found during the prototype demonstrations would likely require more time and money for redesign efforts and retrofitting of test aircraft already in the manufacturing process.

---

<sup>10</sup>Critical drawings are primarily of structural parts weighing more than 5 pounds. The February 2006 critical design review is for both the conventional takeoff and landing variant and the short takeoff and vertical landing variant. The carrier variant will have its own design review about 1 year later.

<sup>11</sup>Drawings include details on the parts and work instructions needed to make the product and reflect the results of testing. Completed drawings allow suppliers to produce the parts so they can be available to the manufacturer when needed for installation on the product.

<sup>12</sup>Manufacturing of the first conventional take-off and landing prototype is currently under way. This aircraft, however, does not include many of the design changes that resulted from the redesign efforts to reduce airframe weight. According to program officials, essentially every drawing used to build this aircraft was affected by the redesign effort.

---

JSF Program Plans to Enter  
Production before Knowledge  
Point 3

In addition to lacking mature technologies and design stability, the JSF program will lack critical production knowledge when it plans to enter low-rate initial production in 2007. Between 2007 and 2013, when the program is scheduled to move to full-rate production, it expects to buy nearly 500 JSF aircraft—20 percent of its planned total buys—at a cost of roughly \$50 billion. Under the program’s preliminary plan, it expects to increase low-rate production from 5 aircraft a year to 143 aircraft a year, significantly increasing the financial investment after production begins.<sup>13</sup> Between 2007 and 2009, the program plans to increase low-rate production spending from about \$100 million a month to over \$500 million a month, and before development has ended and an integrated aircraft has undergone operational evaluations, DOD expects to spend nearly \$1 billion a month. To achieve its production rate, the program will invest significantly in tooling, facilities, and personnel. According to contractor officials, an additional \$1.2 billion in tooling alone would be needed to ramp up the production rate to 143 aircraft a year. Over half of this increase would be needed by 2009—more than 2 years before operational flight testing begins.

Despite this substantial investment, the key event to support the decision to enter low-rate production in 2007 is the JSF’s first flight. Significant commitments will thus be made to JSF production before requisite knowledge is available. This is a much lower standard than called for by best practices. The following are examples of technology, design, and production knowledge that will not have been achieved at the time JSF enters low-rate initial production.

**Technology:** According to information provided by the program office, only one of JSF’s eight critical technologies is expected to be demonstrated in an operational environment by the 2007 low-rate production decision. The remaining seven technologies, which include the complex mission systems and prognostics and health maintenance systems, are not expected to be mature prior to entering production. (See app. III for program office’s projected time frames for demonstrating the eight critical technologies.)

---

<sup>13</sup>The preliminary plan was what was being considered at the time of our review. Since then, in its fiscal year 2006 budget submission, DOD has reduced the planned procurement quantities for the U.S. by 38 aircraft through fiscal year 2011. The preliminary figures also includes planned quantities for the United Kingdom of 2 aircraft in fiscal year 2009, 4 aircraft in fiscal year 2010, 9 aircraft in fiscal year 2011, 9 aircraft in fiscal year 2012, and 10 aircraft in fiscal year 2013.

---

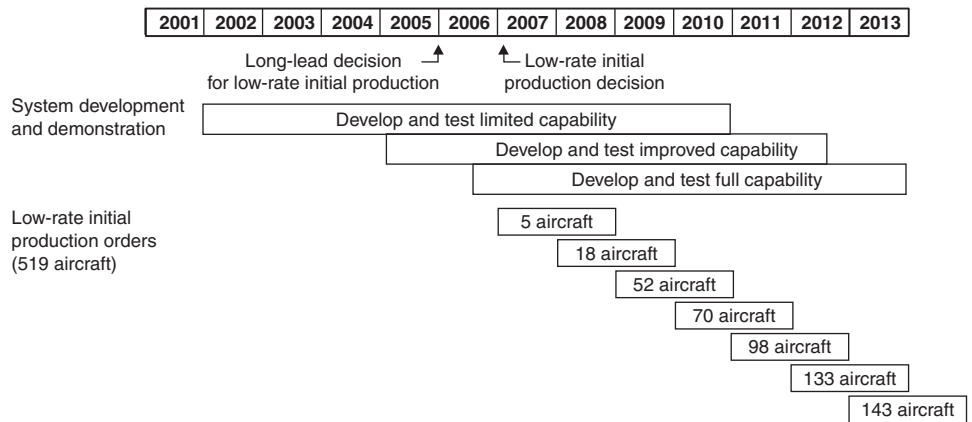
**Design:** Low levels of design knowledge will continue beyond the production decision. Only about 40 percent of the 17 million lines of code needed for the system's software will have been released. The complex software needed to integrate the advanced mission systems is not scheduled for release until about 2010—3 years after JSF is scheduled to enter production. In addition, most structural fatigue testing and radar cross section testing of full-up test articles—needed to verify the stability of the aircraft's structural design—are not planned to be completed until 2010.

**Production:** The program will not demonstrate that critical manufacturing processes are in statistical control when it enters production. At that time, only one test aircraft will be completed and delivered. According to the contractor, manufacturing processes will not be under statistical control until after all of the system development and demonstration aircraft have been built. Also, flight testing of a fully configured and integrated JSF (with critical mission systems and prognostics technologies) is not scheduled until 2011. Operational testing to evaluate the effectiveness and suitability of the integrated system will continue until the full-rate production decision in 2013.

The JSF, like many past DOD weapons programs, is very susceptible to discovering costly problems late in development when the more complex software and advanced capabilities are tested. In the case of the JSF, several hundred aircraft costing several billions of dollars may already be on order or delivered, making any changes that result from testing costly to incorporate. Figure 4 shows the proposed low-rate initial production plan and how it overlaps with development and test activities.



**Figure 4: Overlap of JSF Low-Rate Production and System Development and Demonstration Activities (Includes U.S. and U.K. Quantities)**



Source: GAO analysis of DOD data.

## Failing to Meet Aggressive Delivery Schedule Could Delay Flight Testing

If the JSF program cannot meet aggressive delivery schedules for test aircraft, flight testing will be delayed. Flight testing provides key knowledge about JSF performance needed to make investment decisions for production. The JSF program is attempting to develop three different aircraft, for three different services. All want to fly at supersonic speeds, shoot air-to-air missiles, and drop bombs on a target, but they all have vastly different operational concepts. While each of the variants may look similar externally, subtle design differences provide many needed capabilities that are unique to each service. As a result, the program will attempt to design, build, and test simultaneously three distinct aircraft designs. This difficult task is further complicated by plans to manufacture and deliver in a 5-year period, 15 flight test aircraft and 8 ground test articles. When compared with schedules of other programs with fewer variables, JSF's schedule is aggressive. For example, the F/A-22 program took almost 8 years to manufacture and deliver nine flight test aircraft and two ground test articles of a single aircraft design.

While the first aircraft had only been in assembly for about 8 months, it was already behind schedule as of January 2005. According to the Defense Contract Management Agency, based on the manufacturing status of the center fuselage, wing, forward fuselage, and software development, the first flight, scheduled for August 2006, could be delayed from 2 to 6 months. Late engineering releases to the manufacturing floor have resulted in parts shortages and manufacturing inefficiencies. According to

---

contractor data, as of January 2005, it had taken about 50 percent more labor hours than planned to complete manufacturing efforts.

---

**Program Funding Level Assumptions May Be Difficult to Achieve**

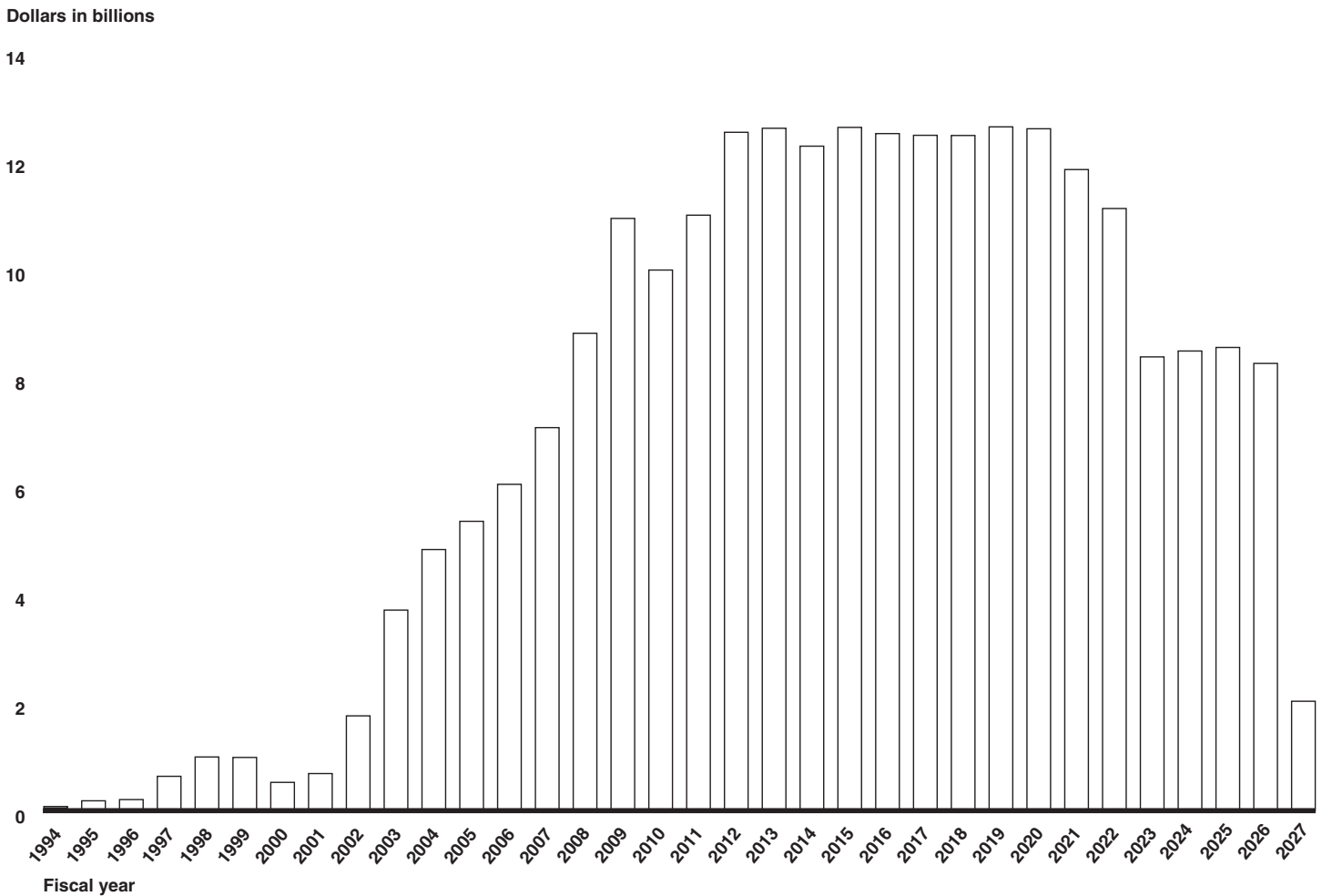
To execute its current acquisition strategy, the JSF program must obtain on average over \$10 billion annually in acquisition funds over the next 2 decades. Regardless of likely increases in program costs, the sizable continued investment in JSF—estimated at roughly \$225 billion over 22 years<sup>14</sup>—must be viewed within the context of the fiscal imbalance facing the nation within the next 10 years. The JSF program will have to compete with many other large defense programs, such as the Army’s Future Combat System and the Missile Defense Agency’s ballistic missile defense system, for funding during this same time frame. There are also important competing priorities external to DOD’s budget. Fully funding specific programs or activities will undoubtedly create shortfalls in others.

Funding challenges will be even greater if the program fails to translate current cost estimates into actual costs. For example, we estimate that another 1-year delay in JSF development would cost \$4 billion to \$5 billion based on current and expected development spending rates. A 10 percent increase in production costs would amount to \$20 billion. The JSF program’s latest planned funding profile for development and procurement—as of December 2003—is shown in figure 5.

---

<sup>14</sup> This figure is based on DOD’s December 2003 JSF cost estimate.

**Figure 5: JSF Program’s Annual Funding Requirements (as of December 2003)**



Source: GAO analysis of DOD data.

**Current Strategy Requires Prolonged Reliance on Cost Reimbursement Contract**

The program’s acquisition strategy is to concurrently develop, test, and produce the JSF aircraft, creating a risky approach. Because of this risk, the program office plans to place initial production orders on a cost reimbursement basis. According to program officials, a cost reimbursable contract is necessary during the initial production phase because of the uncertainties inherent in concurrent development and production programs that prevent the pricing of initial production orders on a fixed-

---

price basis. Cost reimbursement contracts provide for payment of allowable incurred costs, to the extent prescribed in the contract. They are used when uncertainties involved in contract performance do not permit costs to be estimated with sufficient accuracy to use any type of fixed-price contract. Cost reimbursement contracts require only the contractor's "best efforts," thus placing a greater cost risk on the buyer—in this case, DOD. In contrast, a fixed-price contract provides for a pre-established price and places more risk and responsibility for costs and resulting profit or loss on the contractor and provides more incentive for efficient and economical performance. However, to negotiate a fixed-price contract requires certainty about the item to be purchased, which in the case of the JSF will not be possible until late in the development program.

The program plans to transition to a fixed-price contract once the air vehicle has a mature design, has been demonstrated in flight test, and is producible at established cost targets. According to program officials, this transition will occur sometime before full-rate production begins in 2013. The program office believes the combination of the early concept development work, the block development approach, and what it characterizes as the relatively small numbers of aircraft in the initial production buys allow decisions to be made earlier than normal with an acceptable level of risk.

---

## Conclusions

The JSF program is at a crossroads. DOD has not been able to deliver on its initial promises, and the sizable investment DOD plans to make over the next few years greatly raises the stakes to meet future promises. Given the many uncertainties surrounding JSF's development, program officials need more time to gain knowledge before committing to a business case. JSF's failure to adequately match requirements and resources has already resulted in increases in cost, schedule, and performance estimates, and a reduction in DOD's buying power. The new business case must also be accompanied by an acquisition strategy that adopts an evolutionary approach to product development—one that enables knowledge-based investment decisions to maximize remaining program dollars. While the warfighter may not receive the ultimate capability initially, an evolutionary approach provides a useful product sooner and in sufficient quantities to start replacing the rapidly aging legacy fighter and attack force. The decisions DOD makes now and over the next 2 years will greatly influence the efficiency of its remaining funding—over 90 percent of the \$245 billion estimated total program costs. Chief among these are the investments needed to increase production to 143 aircraft a year, increasing production expenditures from \$100 million a month to \$1 billion a month by 2013.

---

While delays are never welcomed, time taken by DOD now to gain more knowledge and reduce risk before increasing its investment may well save time and money later in development and production. Now is the time to get the strategy right for delivering on the remainder of the investment. With an evolutionary, knowledge-based plan in place, DOD managers will be in a better position to succeed in delivering the warfighter needed capabilities within budgeted resources.

---

## Recommendations for Executive Actions

Given that DOD has invested only about 10 percent of the estimated cost to develop and produce the JSF aircraft, and that significant investments are planned in the next few years that can lock the program into a higher-risk acquisition, we recommend the Secretary of Defense take the following two actions to increase the likelihood of having a successful program outcome by delivering capabilities to the warfighter when needed and within available resources:

- (1) Establish an executable program consistent with best practices and DOD policy regarding evolutionary acquisitions. DOD officials should define an affordable first increment, with its own business case that clearly defines the warfighter's most immediate needs and accurately identifies the resources required to deliver on this needed capability. The business case should be established with a high degree of confidence based on known constraints about technology, engineering knowledge, time, and money. For those warfighter needs that cannot be accommodated within this first increment, the program should outline a strategy to meet these needs through subsequent increments, each dependent on having sufficient product knowledge to start system development and demonstration. Each increment should be managed as a distinct acquisition with its own business case for supporting the investment.
- (2) Develop and implement a knowledge-based acquisition approach, as called for by best practices and DOD's acquisition policy, an approach that ensures attainment and use of demonstrated product knowledge before making future investments for each product increment. Before increasing the investment in production resources (tooling, materials, and personnel) greater than investments already in place to support the manufacturing of development test aircraft, the Secretary should ensure knowledge consistent with best practices is captured. This should help minimize the number of low-rate initial production aircraft DOD

---

procures on a cost reimbursement basis, reducing the potential financial risk to the government.

---

## Agency Comments and Our Evaluation

The Office of the Under Secretary of Defense (Acquisition, Technology, and Logistics), provided us with written comments on a draft of this report. The comments appear in appendix I.

DOD partially concurred with our recommendation that the Secretary establish an executable program that includes an affordable first increment with its own business case that clearly defines the warfighter's most immediate needs and accurately identifies the resources required to deliver on this capability. DOD stated that the JSF program acquisition strategy is based on an appropriate balance of technical, cost, and schedule risk considerations to achieve program objectives. Warfighter representatives are involved in determining the content for each block capability, and technology maturity is factored into the decision plan that has been endorsed by DOD leadership. DOD stated its JSF management practices achieve the objectives of the GAO recommendation.

We believe DOD's acquisition strategy will not provide the full benefits of an evolutionary approach as suggested by DOD's policy and best practices. DOD has not structured the JSF development program into increments managed as separate acquisitions with their own cost, schedule, and decision milestones, making the likelihood of successful program outcomes low. The JSF strategy resembles other past major acquisition programs that have attempted to achieve the ultimate capability in a single development increment. DOD has allowed technology development to spill over into product development, weakening any foundation for program cost or schedule estimates. This has led to poor outcomes for other programs, such as the F/A-22 and Comanche, where lengthy and costly development efforts resulted in either program cancellation or a significant reduction in the number of systems to be acquired, a real loss in DOD buying power. Without a true evolutionary approach supported by a business case for each increment, it will be difficult for the JSF program to meet product requirements within current estimates of time and money.

DOD also partially concurred with our recommendation to develop and implement a knowledge-based acquisition approach, which ensures attainment and use of demonstrated product knowledge before making future investments for each product increment. The department agrees that a knowledge-based approach is critical to making prudent acquisition decisions and stated that its current JSF acquisition strategy incorporates

---

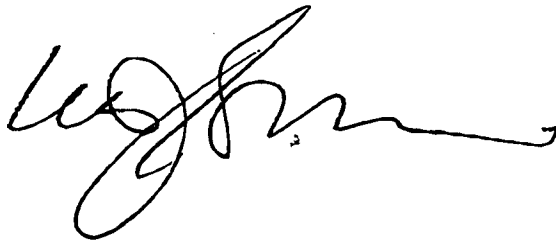
this type of approach. The department admits it has accepted some concurrency between development and production to reduce schedule and cost, but it will consider the production readiness of the JSF design at the low-rate and full-rate production decision milestones. It states that the new program plan includes clear entry and exit criteria for critical milestones to ensure technologies are mature and required incremental objectives are achieved before obligating funds. DOD stated that it conducts regular program reviews, and the Defense Acquisition Board will review program readiness prior to making any milestone decision. The frequent rotation of program leadership ensures ongoing cooperative oversight of emerging challenges and program decisions, and ensures accountability for the implementation of those decisions. Finally, DOD states that the acquisition strategy is consistent with acquisition directives and ensures the department commits resources only after determining that specific developmental or knowledge-based criteria are achieved.

We believe the JSF's acquisition strategy will not capture the right knowledge at the right time for informed decisions on future investments—over \$200 billion dollars. The program does not have the practices in place to capture knowledge at key junctures. DOD will not have captured knowledge before production starts that ensures the design is mature, reliable, and works or that manufacturing processes are in control—keys to successful outcomes in the production phase. Further, the large investments planned in production capability for the JSF over the next few years are vulnerable to costly changes as the aircraft is still being designed and tested. DOD has historically developed new weapon systems in a highly concurrent environment that usually forces acquisition programs to manage technology, design, and manufacturing risk at the same time. While DOD believes it can manage the risk of concurrent development and production by holding regular program reviews and with entrance and exit criteria for decisions, DOD's own experience has shown this approach to be risky and often not totally effective. This has been DOD's traditional approach to weapons acquisition, the same approach that has led to programs costing significantly more than planned and taking much longer to develop. This environment has made it difficult to make informed decisions because appropriate knowledge has not been available at key decision points. If decisions are tied to the availability of critical knowledge, program managers can be held accountable for the timely capture of that knowledge instead of less precise or ill-defined criteria included in risk reduction plans. DOD's practice of frequently changing program managers also decreases accountability because commitments made today will likely not be carried through by the same managers who made the commitments.

---

We are sending copies of this report to the Secretary of Defense; the Secretaries of the Air Force, Army, and Navy; and the Director of the Office of Management and Budget. We will also provide copies to others on request. In addition, the report will be available at no charge on the GAO Web site at <http://www.gao.gov>.

If you or your staff have any questions concerning this report, please contact me at (202) 512-4841 or Michael Hazard at (937) 258-7917. Other staff making key contributions to this report were Marvin Bonner, Matthew Drerup, Matthew Lea, David Schilling, Karen Sloan, and Adam Vodraska.

A handwritten signature in black ink, appearing to read 'Michael J. Sullivan', with a long horizontal flourish extending to the right.

Michael J. Sullivan  
Director  
Acquisition and Sourcing Management



---

*List of Congressional Committees*

The Honorable John Warner  
Chairman  
The Honorable Carl Levin  
Ranking Minority Member  
Committee on Armed Services  
United States Senate

The Honorable Ted Stevens  
Chairman  
The Honorable Daniel K. Inouye  
Ranking Minority Member  
Subcommittee on Defense  
Committee on Appropriations  
United States Senate

The Honorable Duncan Hunter  
Chairman  
The Honorable Ike Skelton  
Ranking Minority Member  
Committee on Armed Services  
House of Representatives

The Honorable C.W. Bill Young  
Chairman  
The Honorable John P. Murtha  
Ranking Minority Member  
Subcommittee on Defense  
Committee on Appropriations  
House of Representatives

# Appendix I: Comments from the Department of Defense



ACQUISITION,  
TECHNOLOGY  
AND LOGISTICS

## OFFICE OF THE UNDER SECRETARY OF DEFENSE

3000 DEFENSE PENTAGON  
WASHINGTON, DC 20301-3000

FEB 24 2005

Mr. Michael J. Sullivan  
Director, Acquisition and Sourcing Management  
U.S. Government Accountability Office  
441 G Street  
N.W. Washington, D.C. 20548

Dear Mr. Sullivan:

This is the Department of Defense (DoD) response to the Government Accountability Office (GAO) draft report, 'TACTICAL AIRCRAFT: DoD Has Opportunity to Reduce Risks in the Joint Strike Fighter (JSF) Program With Different Acquisition Strategy,' dated January 27, 2005, (GAO Code 120355/GAO-05-271). The Department of Defense partially concurs with the two recommendations in the draft report (see enclosure).

The first GAO recommendation is to manage risk with a "first increment" aircraft that meets only the warfighters' most immediate needs. The Department partially concurs.

The ongoing program replan includes a "first increment" block plan. It incorporates restructured spiral development with sequential capability increments to meet the most immediate, achievable warfighting requirements while limiting developmental risk. The re-plan strategy is a balance of technical, cost and schedule risk that incorporates a best practice, evolutionary approach to system acquisition as outlined in the latest Department regulations and instructions.

The second GAO recommendation is to develop and implement a knowledge-based acquisition approach which ensures attainment and use of demonstrated product knowledge before making future investments for each product "increment." The Department partially concurs.

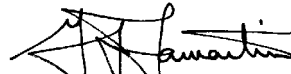
The Department agrees that a knowledge-based approach is critical to making prudent acquisition decisions. The current acquisition strategy incorporates this type of approach with small incremental steps designed to meet the requirements for System Development and Demonstration. The Department has accepted some concurrency between development and production to reduce schedule and cost. The Department will consider the production readiness of the JSF design at the low rate and full rate production



decision milestones based on the program's status at that time. The Defense Acquisition Board will review program readiness in detail and all aspects of concurrency risk will receive careful scrutiny prior to making the necessary milestone decisions.

The Department appreciates the opportunity to comment on the draft report.

Sincerely,



Glenn F. Lamartin  
Director  
Defense Systems

Enclosure:  
As stated

GAO DRAFT REPORT - DATED JANUARY 27, 2005  
GAO CODE 120355/GAO-05-271

"TACTICAL AIRCRAFT: DoD Has Opportunity to Reduce Risks in the Joint Strike  
Fighter Program With Different Acquisition Strategy"

DEPARTMENT OF DEFENSE COMMENTS  
TO THE RECOMMENDATIONS

**RECOMMENDATION 1:** The Government Accountability Office (GAO) recommended that the Secretary of Defense establish an executable program consistent with best practices and DoD policy regarding evolutionary acquisitions. DoD officials should define an affordable first increment, with its own business case that clearly defines the warfighters' most immediate needs and accurately identifies the resources required to deliver on this needed capability. (p. 21/GAO Draft Report)

**DOD RESPONSE:** Partially Concur. The JSF Block plan provides a spiral development approach to acquisition based on an appropriate balance of technical, cost, and schedule risk considerations to achieve program objectives.

JSF program replan includes a block approach to support System Development and Demonstration and Initial Operational Capability. Warfighter representatives are integral to the discussion of content for each block of capability, and technology maturity is factored into the decision plan. The Acting Under Secretary of Defense for Acquisition, Technology and Logistics (USD(AT&L)) endorsed the path forward to resolve the remaining elements of the replan. This replan includes a risk management approach to block capability, the integrated test and evaluation schedule, and funding. The OSD Cost Analysis Improvement Group (CAIG) estimate for the JSF will be presented at the next Defense Acquisition Board (DAB) review to ensure cost risks are understood. The Acting USD(AT&L) also requested that the Joint Program Office update the JSF acquisition strategy for his approval consistent with the President's Budget 2006 submission.

These activities are core tenets of evolutionary acquisition. The Department is confident management practices currently in place achieve the objectives of this GAO recommendation.

**RECOMMENDATION 2:** The GAO recommended that the Secretary of Defense develop and implement a knowledge-based acquisition approach, as called for by best practices and DoD's acquisition policy, which ensures attainment and use of demonstrated product knowledge before making future investments for each product increment. Before increasing the investment in production resources (tooling, materials,

and personnel) greater than that already in place to support the manufacturing of development test aircraft, the Secretary should ensure knowledge consistent with best practices is captured. (p. 22/GAO Draft Report)

**DOD RESPONSE:** Partially Concur. The Department agrees that a knowledge-based approach is critical to making prudent acquisition decisions. The current acquisition strategy incorporates this type of approach with small incremental steps designed to meet the requirements for System Development and Demonstration.

The program replan consists of clear entry and exit criteria for critical milestones to ensure technologies are mature, and required incremental objectives are achieved before obligating funds on subsequent contracts. The Department conducts acquisition reviews via Integrating Integrated Product Teams (IIPT) and Overarching Integrated Product Teams (OIPT), which support Defense Acquisition Board (DAB) reviews. Configuration Steering Board (CSB) and Service Acquisition Executive (SAE) bodies meet quarterly to decide on proposed program changes and ensure associated risks are understood and appropriately resourced

Prior to any updates of desired warfighting capabilities, operational requirements assessments are conducted through an active process of Operational Advisory Group and Senior Warfighting Group reviews. Their recommendations are submitted via the CSB, SAE, IIPT, OIPT, and DAB to ensure risks and costs are considered, and if accepted, budgeted.

The Department has implemented best practices throughout the execution of this important program. One example is the convention of program management oversight periodically alternating between the Departments of the Navy and the Air Force, with a Program Director (PD) who reports to the other Department's Acquisition Executive. This ensures ongoing cooperative oversight management of emerging challenges, decisions in execution, and accountability, for the successful implementation of those decisions across the entire span of the program. The knowledge that oversight will alternate between SAEs helps ensure consistent and constant cooperative oversight on the part of both SAEs as well as the PD. The value of this process has been demonstrated in the five SAE and PD leadership transitions that have been smoothly and seamlessly executed to-date. The standard JSF practice of the Deputy Program Director becoming the PD also significantly contributes to continuity and accountability in program execution.

JSF Program acquisition strategy and execution activities are consistent with the Department's acquisition directives, and ensure the Department commits resources only after determining that specific developmental or knowledge based criteria are achieved.

---

# Appendix II: Scope and Methodology

---

To determine the status of the Joint Strike Fighter (JSF) business case for delivering new capabilities to the warfighter, we compared the original program estimates with current estimates. For development, we used the program estimates that justified the program when it started in 1996. This was the point at which JSF transitioned from a technology development environment to an acquisition program environment, with the commitment to delivery a family of strike aircraft that meet the Air Force, Navy, and Marine Corps needs. At that time, total production, acquisition, and ownership costs had not been estimated. However, the program had estimated the unit flyaway costs for each variant. The total production, acquisition, and ownership estimates were first established to support the decision to enter the system development and demonstration phase in 2001. We used these estimates as the baseline for these costs. We identified changes in costs, quantities, and schedules as well as the causes for the changes. We also identified program conditions that may affect these estimates in the future. To accomplish this, we reviewed management plans, cost reports, progress briefings, program baselines, risk reports, and independent program assessments. We also interviewed officials from the Department of Defense's (DOD) acquisition program management office and prime contractor.

To evaluate whether the current acquisition plan follows an evolutionary, knowledge-based approach to meeting business case goals in the future, we applied GAO's methodology for assessing risks in major weapon systems. This methodology is derived from best practices and experiences of leading commercial firms and successful defense acquisition programs. We reviewed Office of the Secretary of Defense (OSD), program office, and prime contractor processes and management actions. We compared the program's plans and results to date against best practice standards in capturing product knowledge in terms of technology, design, and production maturity information and in applying knowledge to support major program investment decisions. We reviewed management plans, acquisition strategies, test plans, risk assessments, and program status briefings. We identified gaps in product knowledge, reasons for these gaps, and the risks associated with moving forward with inadequate knowledge at future decision points. We also reviewed DOD's acquisition policy to determine whether JSF's approach met its intent.

In performing our work, we obtained information and interviewed officials from the JSF Joint Program Office, Arlington, Virginia; Lockheed Martin Aeronautical Systems, Fort Worth, Texas; Defense Contract Management Agency, Fort Worth, Texas; Institute for Defense Analyses, Alexandria, Virginia; and offices of the Director, Operational Test and Evaluation, and

---

Acquisition, Technology and Logistics, which are part of the Office of Secretary of Defense in Washington, D.C.

# Appendix III: Projected Time Frames for Demonstration of Critical Technologies

<b>Critical technologies</b>	<b>Technology description</b>	<b>Actual or planned date technology demonstrated in relevant environment<sup>a</sup></b>	<b>Actual or planned date technology demonstrated in operational environment<sup>b</sup></b>
Integrated flight propulsion control	Includes integration of propulsion, vehicle management system, and other subsystems as they affect aircraft stability, control, and flying qualities (especially short takeoff and vertical landing). Aircraft improvements are to reduce pilot workload and increase flight safety.	First quarter 2006	Third quarter 2007
Prognostics and health management	Involves the ability to detect and isolate the cause of aircraft problems and then predict when maintenance activity will have to occur on systems with pending failures. Life-cycle cost savings are dependent on prognostics and health management through improved sortie generation rate, reduced logistics and manpower requirements, and more efficient inventory control.	Third quarter 2009	Third quarter 2010
Integrated support system	Involves designing an integrated support concept that includes an aircraft with supportable stealth characteristics and improved logistics and maintenance functions. Life-cycle cost savings are expected from improved logistics and maintenance functions. Life-cycle cost savings are expected from low observable maintenance techniques and streamlined logistics and inventory systems.	Third quarter 2010	Third quarter 2011
Subsystems	Includes areas of electrical power, electrical wiring, environmental control systems, fire protection, fuel systems, hydraulics, landing gear systems, mechanisms and secondary power. Important for reducing aircraft weight, decreasing maintenance cost, and improving reliability.	Demonstrated in 2002	Demonstrated in 2004
Integrated core processor	Includes the ability to use commercial-based processors in an open architecture design to provide processing capability for radar, information management, communications, etc. Use of commercial processors reduces development and production costs, and an open architecture design reduces future development and upgrade costs.	Third quarter 2009	First quarter 2011
Radar	Includes advanced integration with communication, navigation, and identification functions and electronic warfare functions through improved apertures, antennas, modules, radomes, etc. Important for reducing avionics cost and weight, and decreasing maintenance cost through improved reliability.	Fourth quarter 2007	Fourth quarter 2008



**Appendix III: Projected Time Frames for  
Demonstration of Critical Technologies**

<b>Critical technologies</b>	<b>Technology description</b>	<b>Actual or planned date technology demonstrated in relevant environment<sup>a</sup></b>	<b>Actual or planned date technology demonstrated in operational environment<sup>b</sup></b>
Mission systems integration	Involves decreasing pilot workload by providing information for targeting, situational awareness, and survivability through fusion of radar, electronic warfare, and communication, navigation, and identification data. Improvements are achieved through highly integrated concept of shared and managed resources, which reduce production costs, aircraft weight, and volume requirements, in addition to providing improved reliability.	First quarter 2010	Fourth quarter 2011
Manufacturing	Involves lean, automated, highly efficient aircraft fabrication and assembly techniques. Manufacturing costs should be less through improved flow time, lower manpower requirements, and reduced tooling cost.	Second quarter 2007	Second quarter 2007

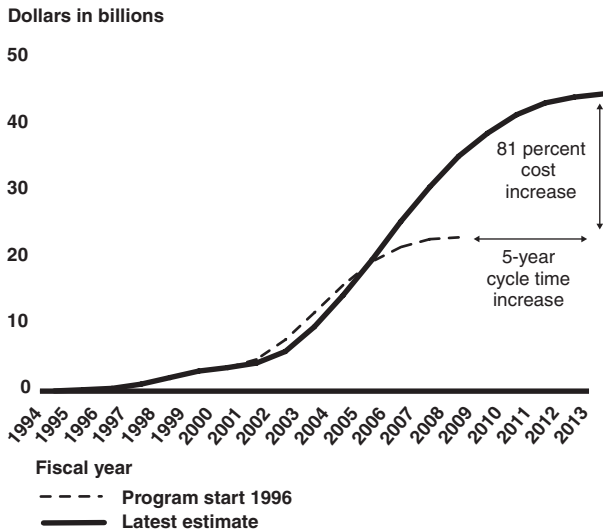
Source: Joint Strike Fighter Program Office.

<sup>a</sup>Technology is in a form that closely represents the form, fit, and function needed for the JSF and is demonstrated in an environment that closely approximates the realities of its intended use but is short of the eventual operating environment itself, such as in a high-fidelity laboratory.

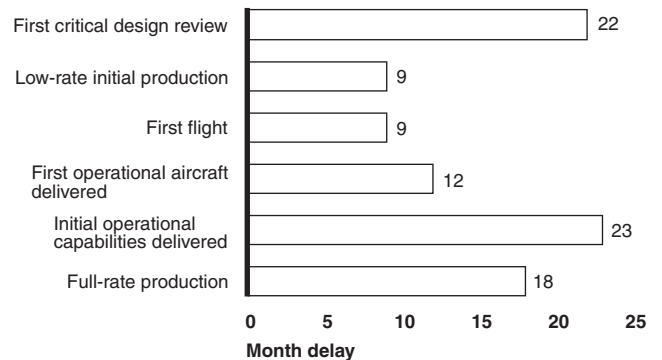
<sup>b</sup>Technology is in the form, fit, and function needed for the JSF and is demonstrated in an operational environment similar to that intended for the JSF, such as on a surrogate platform or test bed.

# Appendix IV: Measures of JSF Program Cost and Schedule Changes

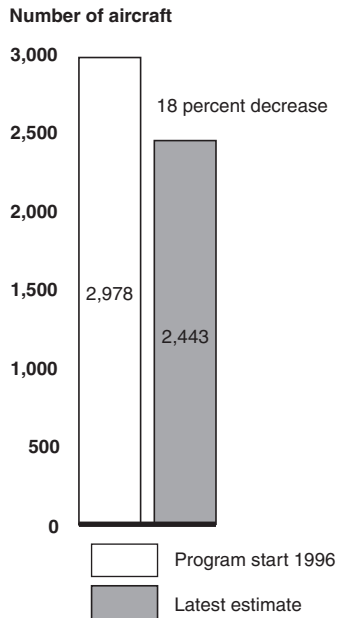
Development costs and cycle time have increased



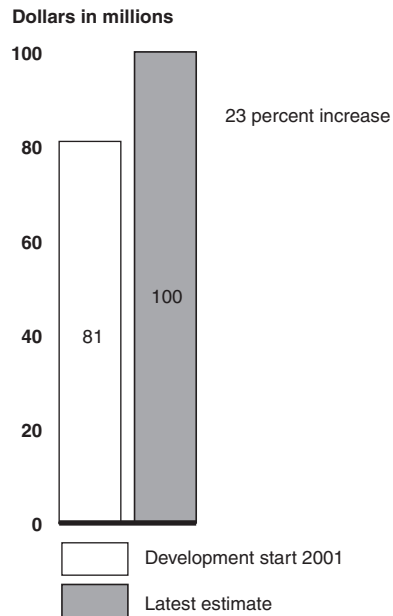
Key events delayed since development start in 2001



Procurement quantities have decreased



Total program acquisition unit costs have increased



Source: GAO analysis of DOD data.

---

## GAO's Mission

The Government Accountability Office, the audit, evaluation and investigative arm of Congress, exists to support Congress in meeting its constitutional responsibilities and to help improve the performance and accountability of the federal government for the American people. GAO examines the use of public funds; evaluates federal programs and policies; and provides analyses, recommendations, and other assistance to help Congress make informed oversight, policy, and funding decisions. GAO's commitment to good government is reflected in its core values of accountability, integrity, and reliability.

---

## Obtaining Copies of GAO Reports and Testimony

The fastest and easiest way to obtain copies of GAO documents at no cost is through GAO's Web site ([www.gao.gov](http://www.gao.gov)). Each weekday, GAO posts newly released reports, testimony, and correspondence on its Web site. To have GAO e-mail you a list of newly posted products every afternoon, go to [www.gao.gov](http://www.gao.gov) and select "Subscribe to Updates."

---

## Order by Mail or Phone

The first copy of each printed report is free. Additional copies are \$2 each. A check or money order should be made out to the Superintendent of Documents. GAO also accepts VISA and Mastercard. Orders for 100 or more copies mailed to a single address are discounted 25 percent. Orders should be sent to:

U.S. Government Accountability Office  
441 G Street NW, Room LM  
Washington, D.C. 20548

To order by Phone: Voice: (202) 512-6000  
TDD: (202) 512-2537  
Fax: (202) 512-6061

---

## To Report Fraud, Waste, and Abuse in Federal Programs

Contact:

Web site: [www.gao.gov/fraudnet/fraudnet.htm](http://www.gao.gov/fraudnet/fraudnet.htm)

E-mail: [fraudnet@gao.gov](mailto:fraudnet@gao.gov)

Automated answering system: (800) 424-5454 or (202) 512-7470

---

## Congressional Relations

Gloria Jarmon, Managing Director, [JarmonG@gao.gov](mailto:JarmonG@gao.gov) (202) 512-4400  
U.S. Government Accountability Office, 441 G Street NW, Room 7125  
Washington, D.C. 20548

---

## Public Affairs

Paul Anderson, Managing Director, [AndersonP1@gao.gov](mailto:AndersonP1@gao.gov) (202) 512-4800  
U.S. Government Accountability Office, 441 G Street NW, Room 7149  
Washington, D.C. 20548