

March 2007

# JOINT STRIKE FIGHTER

## Progress Made and Challenges Remain



# Report Documentation Page

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Highlights of [GAO-07-360](#), a report to congressional committees

### Why GAO Did This Study

The Joint Strike Fighter (JSF) program—a multinational acquisition program for the Air Force, Navy, Marine Corps, and eight cooperative international partners—is the Department of Defense’s (DOD) most expensive aircraft acquisition program. DOD currently estimates it will spend \$623 billion to develop, procure, and operate and support the JSF fleet. The JSF aircraft, which includes a variant design for each of the services, represents 90 percent of the remaining planned investment for DOD’s major tactical aircraft programs. In fiscal year 2004, the JSF program was rebaselined to address technical challenges, cost increases, and schedule overruns.

This report—the third mandated by Congress—describes the program’s progress in meeting cost, schedule, and performance goals since rebaselining and identifies various challenges the program will likely face in meeting these goals in the future.

### What GAO Recommends

GAO is recommending that DOD limit annual production quantities to no more than 24 aircraft per year until each variant’s basic flying qualities have been demonstrated in flight testing now scheduled in the 2010 time frame. DOD non-concurred, believing its current strategy provides a balance of technical risk, financial constraints, and operational needs.

[www.gao.gov/cgi-bin/getrpt?GAO-07-360](http://www.gao.gov/cgi-bin/getrpt?GAO-07-360).

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).

## JOINT STRIKE FIGHTER

### Progress Made and Challenges Remain

#### What GAO Found

The JSF program has delivered and flown the first development aircraft. However, cost and schedule goals established in the fiscal year 2004 rebaselined program have not been met. Total JSF program acquisition costs (through 2027) have increased by \$31.6 billion and now DOD will pay 12 percent more per aircraft than expected in 2004. The program has also experienced delays in several key events, including the start of the flight test program, delivery of the first production representative development aircraft, and testing of critical missions systems. Delays in the delivery of initial development aircraft were driven by incomplete engineering drawings, changes in design, manufacturing inefficiencies, and parts shortages. Despite these delays, the program still plans to complete development in 2013, compressing the amount of time available for flight testing and development activities. Also, the program projects it will meet all but one key performance requirement—line of sight communications—that is currently dependent on other capabilities being developed outside the JSF program.

Accurately predicting JSF costs and schedule and ensuring sufficient funding will likely be key challenges facing the program in the future. JSF continues to pursue a risky acquisition strategy that concurrently develops and produces aircraft. While some concurrency may be beneficial to efficiently transition from development to production, the degree of overlap is significant on this program. Any changes in design and manufacturing that require modifications to delivered aircraft or to tooling and manufacturing processes would result in increased costs and delays in getting capabilities to the warfighter. Low-rate initial production will begin this year with almost the entire 7-year flight test program remaining to confirm the aircraft design. Confidence that investment decisions will deliver expected capability within cost and schedule goals increases as testing proves the JSF will work as expected. The JSF program also faces funding uncertainties as it will demand unprecedented funding over the next 2 decades—more than \$12.6 billion a year on average through 2027.

**Overlap of Production Investments and Testing**

	2007	2008	2009	2010	2011	2012	2013
Cumulative production investment (in billions of dollars)	\$0.9	\$3.7	\$7.4	\$13.5	\$20.4	\$31.0	\$41.9
Cumulative aircraft	2	14	30	60	103	185	275
Percentage of flight test program completed	1%	3%	13%	35%	56%	77%	98%

**Limited knowledge gained from flight tests** **More knowledge gained from flight tests**

*Increasing confidence in investment outcomes*

Source: DOD data, as of February 2007; GAO analysis and presentation.

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## **Abbreviations**

CAIG	Cost Analysis and Improvement Group
DCMA	Defense Contract Management Agency
DOD	Department of Defense
JSF	Joint Strike Fighter

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United States Government Accountability Office  
Washington, DC 20548

March 15, 2007

Congressional Committees

The Joint Strike Fighter (JSF) is the Department of Defense's (DOD) most expensive aircraft acquisition program. The JSF aircraft design includes three variants to be used by the Air Force, Navy, Marine Corps, and eight cooperative international partners. JSF is a central part of DOD's overall recapitalization strategy for its tactical aircraft fleet, representing 90 percent of the remaining planned investment for its major tactical aircraft programs. DOD currently estimates it will spend \$276 billion to develop and procure about 2,443 aircraft and related support equipment by 2027 and an additional \$347 billion to operate and support these aircraft once they have been fielded.

The Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 (P.L. 108-375) requires GAO to review the JSF program annually for 5 years.<sup>1</sup> In the past 2 years, we issued reports identifying opportunities for the program to reduce risks and improve the chance for more successful outcomes. We recommended DOD pursue an acquisition strategy consistent with best practices and DOD policy preferences regarding evolutionary and knowledge-based acquisitions including deferring production investments until the aircraft have been proven to work in flight testing.<sup>2</sup> DOD has taken no direct actions in response to these recommendations and has stated that its current acquisition approach fulfills the intent of DOD policy and further limits on production are unnecessary. In 2006 Congress reduced the number of production aircraft to be funded in fiscal year 2007 and the number of aircraft to receive advanced procurement funds for aircraft to be procured in fiscal year 2008.

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<sup>1</sup> Section 213 of the Act requires us to assess the extent to which the system development and demonstration program is currently meeting 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>2</sup> GAO, *Joint Strike Fighter: DOD Plans to Enter Production before Testing Demonstrates Acceptable Performance*, [GAO-06-356](#) (Washington D.C.: Mar. 15, 2006) and *Tactical Aircraft: Opportunity to Reduce Risks in the Joint Strike Fighter Program with Different Acquisition Strategy*, [GAO-05-271](#) (Washington D.C.: Mar. 15, 2005).

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This report assesses the progress of the JSF program since it was rebaselined in fiscal year 2004 to add resources needed to address technical problems. Specifically, we (1) determined the JSF program's progress in meeting cost, schedule, and performance goals; and (2) identified the challenges and risk the program will face in meeting these goals in the future. We performed our work from June of 2006 to March of 2007 in accordance with generally accepted government auditing standards. For more information on our scope and methodology, see appendix I.

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. We were provided sufficient information to measure the program's progress in meeting its goals based on cost data provided in April 2006 as well as the challenges that remain for the program. At the time of our review, DOD was still preparing its new cost estimate to be included in the program's Selected Acquisition Report dated December 31, 2006, expected to be delivered to the Congress by April 2007. Because the new cost estimate for the JSF program will not be available until after this report is issued we are unable to make informed judgments on those estimated costs. It should be noted that after our 2006 report was issued on March 15, 2006, DOD released its December 2005 Selected Acquisition Report, which showed an increase of over \$19 billion in estimated JSF program costs.

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## Results in Brief

The JSF program has delivered and flown the first development aircraft and has started manufacturing additional development aircraft for the test program. JSF program costs have increased by \$31.6 billion since the program was rebaselined in fiscal year 2004. As a result, DOD will pay more per aircraft than was expected when the program was rebaselined. The program has also experienced delays in the start of the flight test program but has not changed the dates for completing development reducing the amount of time available for flight testing and development activities. Late design drawings, changes in design and manufacturing processes, and late subsystem deliveries caused delays that prevented timely manufacturing and delivery of development aircraft. The program currently projects that the JSF will meet all but one of its key performance requirements—ability to fully interoperate with other platforms. These performance projections are based largely on engineering analysis, modeling, and laboratory testing and not on flight testing.

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The degree of concurrency between development and production in the JSF program's acquisition strategy still includes significant risks for cost and schedule overruns or late delivery of promised capabilities to the warfighter. For example, at the time of the low-rate initial production decision, one aircraft will have flown, less than 1 percent of the test program will have been completed, and none of the three variants will have a production representative prototype built. It will not be until about 2012 that a fully capable, integrated JSF is scheduled to begin flight testing. A 7-year flight test program that includes over 11,000 hours of testing just began in December 2006. Therefore, almost all of critical flight testing remains to confirm that the aircraft will indeed deliver the required performance. Manufacturing and technical problems can delay the completion of a flight test program, increase the number of flight test hours needed to verify that the system will work as intended, and affect when capabilities are delivered to the warfighter. The program also faces uncertainties with the amount of funding that will be available to support the program's plan. The program will demand unprecedented amounts of annual funds over the next 2 decades—more than \$12.6 billion a year on average. Other DOD review and oversight organizations have expressed similar concerns over the level of risk in the program that will challenge the completion within estimated cost and schedule.

To improve chances of a successful outcome, we are recommending that the Secretary of Defense limit annual production quantities to no more than 24 aircraft per year, the current manufacturing capacity, until each variant's basic flying qualities have been demonstrated in flight testing now scheduled in the 2010 time frame.

DOD non-concurred with our recommendation stating that the current JSF acquisition strategy provides an effective balance of technical risk, financial constraints, and operational needs of the services. However, we believe DOD's actions to reduce aircraft quantities in the fiscal year 2008 President's Budget are in line with our recommendation to limit production to current manufacturing capacity until each variant's flying qualities have been demonstrated in flight testing. In the 2008 budget, DOD reduced the number of production aircraft it plans to buy during the flight test program by about 35 percent as compared to its previous plan for the JSF. Under this new plan DOD does not substantially increase its buy quantities of production aircraft until 2011. We continue to believe that limiting production quantities until the design is demonstrated would reduce the overlap in production and development while still allowing the efficient transition from development to production. It would also make



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cost and schedule more predictable and lessen the risk to DOD's production investment.

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## 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, JSF will incorporate low observable technologies, defensive avionics, advanced onboard and offboard sensor fusion, internal and external weapons, and advanced prognostic maintenance capability. According to DOD, these technologies represent a quantum leap over legacy tactical aircraft capabilities. At the same time, the JSF aircraft design includes three variants: a conventional take-off and landing variant for the Air Force; an aircraft carrier-suitable variant for the Navy; and a short take-off and vertical landing variant for the Marine Corps and the United Kingdom. JSF is intended to replace a substantial number of aging fighter and attack aircraft in DOD's current inventory.

In 2003 the JSF program system integration efforts and a preliminary design review 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. The program's inability to meet its ambitious goals resulted in the Department's failing to deliver on the business case that justified initial investment in JSF. As a result, purchase quantities have been reduced, total program costs have increased, and delivery of the initial aircraft has been delayed. These changes have effectively reduced DOD's buying power for its investment as it will now be buying fewer aircraft for a greater financial investment. It is too late for the program to meet these initial promises. To its credit, in fiscal year 2004, DOD rebaselined the program extending development by 18 months and adding resources to address problems discovered during systems integration and the preliminary design review. Program officials also 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. Table 1 shows the evolution of cost and delivery estimates from the start of the program up to the latest official program information as of December 2005.

**Table 1: Changes in JSF Program Purchase Quantities and Costs**

	November 1996 (program start)	October 2001 (system development start)	December 2003 <sup>a</sup> (rebaseline)	December 2005 <sup>a</sup> (latest available data)
<b>Expected Quantities</b>				
Development quantities	10	14	14	15
Procurement quantities (U.S. only)	2,978	2,852	2,443	2,443
<b>Total Quantities</b>	<b>2,988</b>	<b>2,866</b>	<b>2,457</b>	<b>2,458</b>
<b>Cost Estimates (Then Year \$ in billions)</b>				
Development	\$24.8	\$34.4	\$44.8	\$44.5
Procurement	Not available	196.6	199.8	231.7
Other	Not available	2.0	0.2	0.2
<b>Total Program Acquisition</b>	<b>Not available</b>	<b>\$233.0</b>	<b>\$244.8</b>	<b>\$276.5<sup>b</sup></b>
<b>Unit Cost Estimates (Then Year \$ in millions)</b>				
Program acquisition	Not available	\$81	\$100	\$112
Average procurement	Not available	69	82	95
<b>Estimated Delivery Dates</b>				
First operational aircraft delivery	2007	2008	2009	2009
Initial operational capability	2010	2010-2012	2012-2013	2012-2015 <sup>c</sup>

Source: GAO analysis of DOD data.

<sup>a</sup>The Selected Acquisition Reports are dated December 2003 and 2005 but are not officially released until March or April of the following year.

<sup>b</sup>Numbers may not add due to rounding.

<sup>c</sup>Recent program and President's budget information indicates that initial operational capability for the Navy's carrier variant has been rescheduled from the second quarter of 2013 to the first quarter of 2015.

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**Program Cost  
Estimates Have  
Increased  
Significantly and  
Critical Milestones  
Have Been Delayed  
Since the JSF Was  
Rebaselined**

Since establishing a new program baseline in fiscal year 2004, JSF program costs have risen and key events have been delayed. JSF program costs have increased by \$31.6 billion since the program's decision to rebaseline in fiscal year 2004. This includes a \$19.8 billion increase in costs since our report last year in March 2006. The program has experienced delays in several key events including delays in the start of the flight test program, manufacturing and delivery of the first development aircraft, and delays in the testing of critical missions systems. These delays reduce the amount of time available for completing flight testing and development activities. The program projects that it will meet its key performance requirements except for one dealing with the warfighter's ability to fully interoperate with other platforms. Projections are based largely on engineering analysis, modeling, and laboratory testing, and a 7-year test program to demonstrate performance just started in December 2006.

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**Total Program Cost  
Estimates Have Increased**

JSF program cost estimates have increased by \$31.6 billion since the program's decision to rebaseline in fiscal year 2004. During this period, estimates in some cost areas grew by \$48 billion but were offset by \$16.4 billion due to quantity changes and the proposed termination of an alternate engine program. According to the program, the cost estimate is still mostly based on cost estimating relationships—like cost per pound—not actual costs and, therefore, is subject to change as the program captures the actual costs to manufacture the aircraft. Also, the official program estimate is based on the program's December 31, 2005, Selected Acquisition Report delivered to Congress in April 2006. We could not review the most recent estimated costs of the JSF program. This information is being used by the Office of the Secretary of Defense in preparing its fiscal year 2008 budget request as well as for the program's Selected Acquisition Report dated December 31, 2006, expected to be delivered to the Congress in early April 2007. Although the most recent estimates were not available for this review, we expect that, unless program content is changed, future cost estimates will be higher based on the history of similar acquisition programs and the risks that remain in the program. Table 2 shows the changes to the program's costs since the rebaseline in fiscal year 2004.

**Table 2: JSF Cost Estimate Changes since the Rebaseline**

(Then-year dollars in billions)	Research, development, test and evaluation	Procurement	Total
<b>December 2003 estimated costs</b>	<b>\$44.8</b>	<b>\$199.8</b>	<b>\$244.6<sup>a</sup></b>
Cost growth	1.8	46.2	48.0
Cost reductions	(2.1)	(14.3)	(16.4)
Elimination of alternate engine program	(2.1)	(5.1)	(7.2)
Benefits from including partner quantities	—	(9.2)	(9.2)
<b>December 2005 estimated costs</b>	<b>\$44.5</b>	<b>\$231.7</b>	<b>\$276.2<sup>a</sup></b>
Dollar change	\$(0.3)	\$31.9	\$31.6
Percent change	(0.6)	16	13

Source: GAO analysis of DOD data.

<sup>a</sup>Does not include estimated military construction costs.

Since our last report, the program estimated a \$19.8 billion net increase in its total program costs. The majority of the cost growth, over 95 percent, was for procurement. According to the program office, several factors led to an increase in the procurement cost estimate. The most significant increases include:

- \$10.3 billion—result of design and manufacturing changes to large bulkheads in the wing section of the aircraft, need for 6 times more aluminum and almost 4 times more titanium than originally estimated. At the same time, titanium costs almost doubled.
- \$3.5 billion—result of reduced manufacturing efficiency because of plans to build a certain number of wings at a new subcontractor.
- \$5.5 billion—result of changing the business relationship of the prime and two major subcontractors.
- \$4.4 billion—result of projected higher support costs.
- \$14.7 billion—result of changing assumptions for estimating labor rates and inflation.

The increases in procurement costs were offset by two main factors. First, the cost estimate reflects production efficiency benefits of \$9.2 billion from producing 508 international partner aircraft that were not included in previous estimates. Secondly, the program reduced procurement costs by \$5.1 billion as a result of the proposed elimination of the alternate engine program. According to the program office, it expected savings from manufacturing efficiencies by having one engine contractor producing a larger quantity of engines. Program officials stated that they have had difficulty quantifying cost savings that might accrue from competing

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engine buys between contractors. For now Congress has reinstated the alternate engine program and has required further analysis from DOD and others on the costs of the program.<sup>3</sup>

The program also reported that development costs decreased by \$1.2 billion. The reduction in development costs was due almost entirely to the removal of the remaining estimated costs to complete the alternate engine's development. Again, Congress has since reinstated funding for the alternate engine program.

The net effect of the JSF program cost increases is that DOD will pay more per aircraft than expected when the program was rebaselined. The average procurement unit costs have increased from \$82 million to almost \$95 million and the program acquisition unit costs has increased from \$100 million to over \$112 million.

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### Delays in Key Program Events Have Compressed the Development Schedule

Since the JSF program was rebaselined, it has experienced delays in several key development activities but without corresponding changes to the end of development. Holding firm to these dates forces the program to find ways to complete development activities in less time, especially if problems are discovered in the remaining 6 years of development. The program office is evaluating different ways to reduce the risk of this compression by being more efficient in its flight test activities. The first JSF flight was scheduled for August 2006 but did not occur until mid December 2006—about 4 months later than expected. According to the program office, the first flight was successful but was shortened because of a problem with instrumentation on the aircraft. Although the first aircraft will be able to demonstrate some performance—limited flying qualities, propulsion, and vehicle subsystems—it is not a production representative aircraft with fully functioning critical mission systems or the design changes from the rebaselined program that reduced airframe weight.

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<sup>3</sup> In section 211 of the John Warner National Defense Authorization Act for Fiscal Year 2007 (P.L. 109-364), Congress required independent cost analyses of the alternate engine program by March 15, 2007, from the DOD Cost Analysis Improvement Group, a Federally Funded Research and Development Center selected by DOD, as well as GAO.

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**Figure 1: First JSF Development Aircraft in Flight**

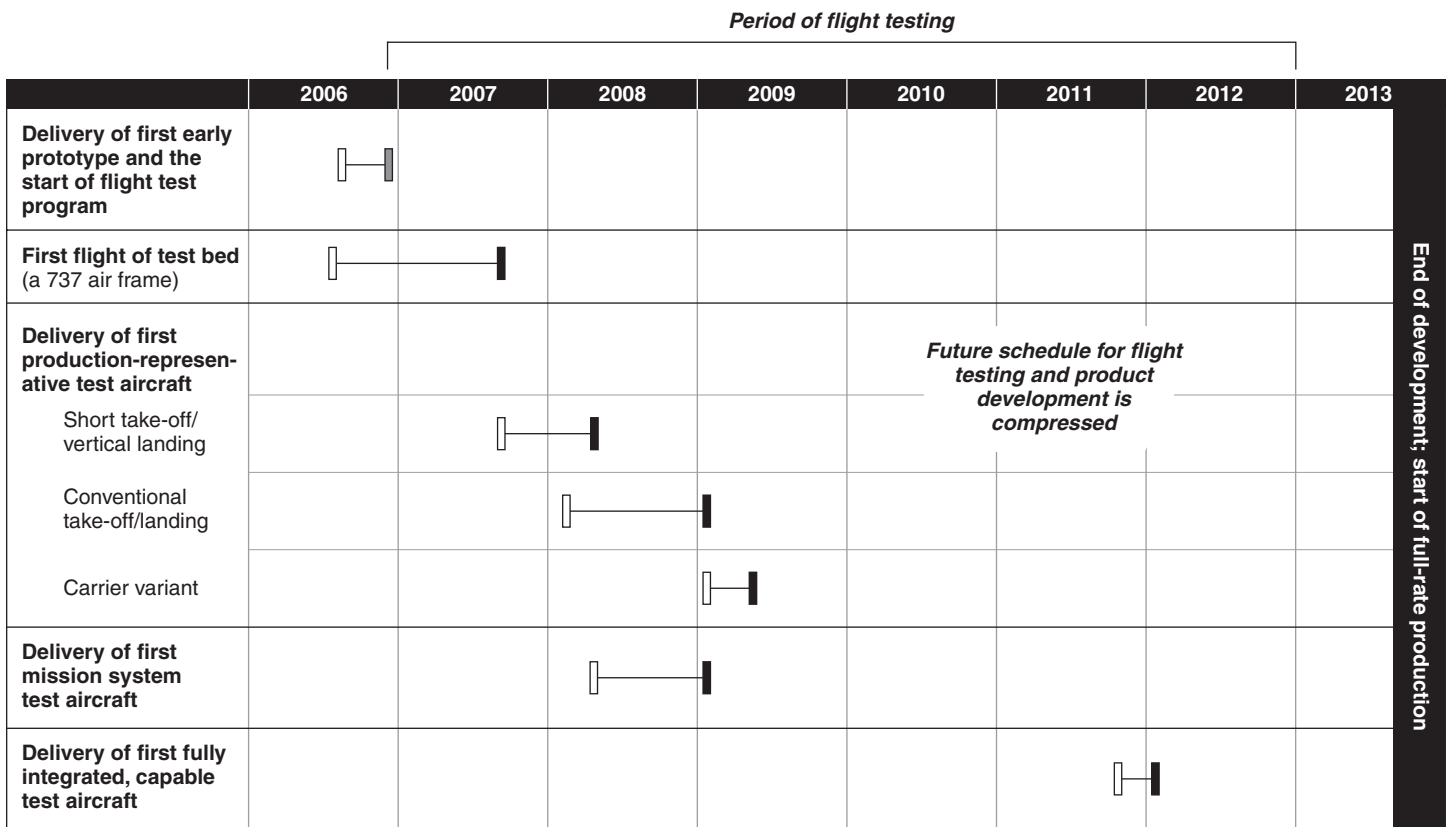


Source: JSF program office.

The first flight of a production representative aircraft has been delayed 8 months to May 2008. This aircraft will be a short take-off and vertical landing variant and will incorporate the design changes from the rebaselined program. According to the latest program information, the first fully integrated, capable JSF is scheduled to begin testing in the early 2012 time frame, a delay of several months. The first flight of a JSF with limited mission capability has been delayed 9 months. The estimate for first flight of a production representative conventional take-off variant has been delayed 11 months to January 2009 and the first flight of a carrier variant has been delayed by as much as 4 months to May 2009.

The flying test bed, also critical to reducing risk in the flight test program, has been delayed about 14 months to late 2007. This aircraft is a modified Boeing 737 that will be equipped with the sensors and mission system software and hardware. The test bed will allow the program to test aircraft mission systems such as target tracking and detection, electronic warfare, and communications. Figure 2 shows schedule delays and the compression in the development schedule.

**Figure 2: Changes in JSF Scheduled Events since the Replan**



- Event did not or has not occurred
- Event has occurred
- New date for event

Source: DOD (2007 data); GAO (analysis and presentation).

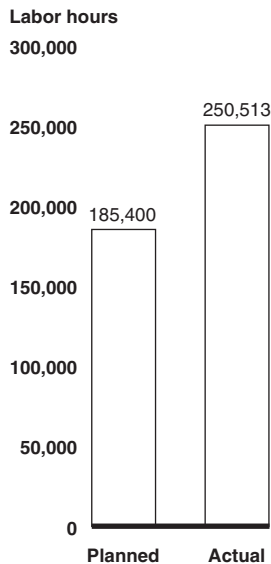
### Design and Manufacturing of Development Aircraft Has Been a Major Source of Delay

The program has completed manufacturing of its first development aircraft and manufacturing data indicates that the program did not meet its planned labor hour goals. Manufacturing data on subsequent development aircraft that have begun manufacturing indicate these aircraft are not currently meeting their planned manufacturing efficiencies either. According to contractor data as of November 2006, the first development aircraft had required 35 percent or 65,113 more labor hours than expected. The program encountered most of the inefficiencies in the mate and delivery phase and with the fabrication of the center fuselage and wing.

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Figure 3 shows the planned hours versus the actual hours needed for completing the first test aircraft.

**Figure 3: Manufacturing Efficiency of First Test Aircraft as of November 2006**



Source: Lockheed Martin (data), GAO (analysis).

When the first aircraft began manufacturing, the program had released about 20 percent of the engineering drawings needed for building the aircraft. This led to a backlog of drawings, negatively impacting the availability of parts needed for efficient manufacturing operations. To compensate for delays and parts shortages for production, components of the aircraft were manufactured out of sequence and at different manufacturing workstations than planned. For example, the wing section was mated to the center fuselage before work on the wing was completed. The wing was only 46 percent complete and still required more than 18,500 hours of work. Because this remaining work was completed at a different workstation than was planned, contractor officials stated that major tooling—such as a stand that supports the wing structure upright to allow workers to install wiring and other parts—was not available for use. As a result, workers were required to lie on the ground or bend under or over the wing structure to complete the wing assembly, significantly increasing the number of hours needed to complete this effort. According to Defense Contract Management Agency, out-of-station work performed on the wing required an additional 46 percent more hours than planned. Late delivery of parts and late qualification of subsystems were the major



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drivers to the mate and delivery inefficiencies, more than doubling the hours needed to complete this activity.

Lockheed Martin, the prime contractor, appears to be focused on developing an efficient and effective manufacturing process for the JSF, but it is still very early in that process. The development aircraft now in manufacturing are not currently meeting their planned efficiencies. As with the first test aircraft, the program does not expect to manufacture the development aircraft in the planned manufacturing sequence. The program expects to move some wing fabrication activities to final assembly and do both fabrication and final assembly concurrently. Early development aircraft are already experiencing inefficiencies and delays. As of December 2006, wing manufacturing data for one of these aircraft shows the program had completed less than 50 percent of the activities expected at this time while requiring 41 percent more hours than planned. According to the contractor and program officials, these inefficiencies are largely due to late delivery of the wing bulkheads because of a change in their manufacturing process. The Defense Contract Management Agency has rated manufacturing as high risk, stating that the primary cause of risk is the late delivery of parts to properly support the manufacturing work flow. It projects further delays to schedule, increased costs, and subsequent out-of-sequence work.

An early indicator of design stability is the completion of design drawings at the critical design review. In February 2006, the program held its critical design review for production representative conventional and short take-off and vertical landing aircraft.<sup>4</sup> At that time, the program had completed 47 percent of the short take-off aircraft design and 3 percent of the conventional aircraft design. Our previous best practices work suggests that completion of 90 percent of a product's engineering drawings provides tangible evidence that the design is stable. As with the first aircraft, the program has experienced late releases of engineering drawings, which has delayed the delivery of critical parts from suppliers to manufacturing for the building of the initial aircraft. For example, based on program data as of October 2006, more than one-third of the drawings needed to complete these two variants are expected to be released late to manufacturing.

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<sup>4</sup> Critical design review for the carrier variant has been rescheduled from late 2006 to spring 2007. According to program officials, this delay will allow the program to mature the design of the variant.

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Although the first aircraft encountered manufacturing inefficiencies, the JSF Program and the contractor have pointed to some successes in this initial manufacturing effort. For example, they have stated the mate of the major sections of the aircraft was more efficient than in past aircraft programs because of the state-of-the-art tools used to design the aircraft and develop the manufacturing process. Likewise, they have indicated that they have experienced fewer defects in this first aircraft than experienced on legacy aircraft.

We would agree that the contractor has made progress in demonstrating the use of several large tools and fabrication processes in building the first test aircraft. However, a key factor in developing an efficient and effective manufacturing process is a mature aircraft design. Major design modifications can cause substantial and costly changes in the manufacturing process. For example, since the first aircraft entered production, the manufacturing process has had to be altered due to redesigning required to resolve weight and performance problems. According to Defense Contract Management Agency officials, some tools already bought and in place were either no longer useful or being used less efficiently. New tools had to be procured and the manufacturing process had to change. The Defense Contract Management Agency noted that these additional tooling costs were about \$156 million. Contractor officials stated that the current manufacturing capacity is sufficient to produce about 24 aircraft per year. Given that only one aircraft has been built and essentially all of the flight and static and durability testing remains to be done there is still significant risk that the JSF design for each of the three variants will incur more changes as more design knowledge is gained.

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### The JSF Program Projects Key Performance Parameters Will Be Met Based on Modeling and Simulations

Currently, the JSF program estimates that by the time the development program ends the aircraft design will meet all but one of its key performance parameters. The performance estimates to date are based on engineering analyses, computer models, and laboratory tests. Key performance parameters are defined as the minimum attributes or characteristics considered most essential for an effective military capability—for the JSF there are eight parameters. The program office estimates that seven of the eight key performance parameters are being met. The aircraft is currently not meeting its full interoperability performance parameter due to a requirement for beyond-line-of-sight communications. Meeting the full interoperability required is currently dependent on other capabilities being developed outside the JSF program. Most ground and flight tests will have to be completed before all the key performance estimates are confirmed. At this time, the program has

completed less than 1 percent of the flight test program and no structural or durability tests have been started. According to the program's test and evaluation master plan, the key performance parameters will be verified during testing from 2010 to 2013. Table 3 shows the program's estimate for each key performance parameter.

**Table 3: JSF Program Estimates for Achieving Key Performance Parameters**

Key performance parameter	Status		Confirmed through flight testing	
	Meeting	Not meeting	Yes	No
Combat radius	●			●
CV Recovery	●			●
STOVL Performance	●			●
Interoperability		●		●
Radio frequency signature	●			●
Mission reliability	●			●
Sortie Generation Rate	●			●
Logistics footprint	●			●

Source: GAO analysis of JSF program office data.

## Challenges Remain in Executing the Balance of the JSF Program

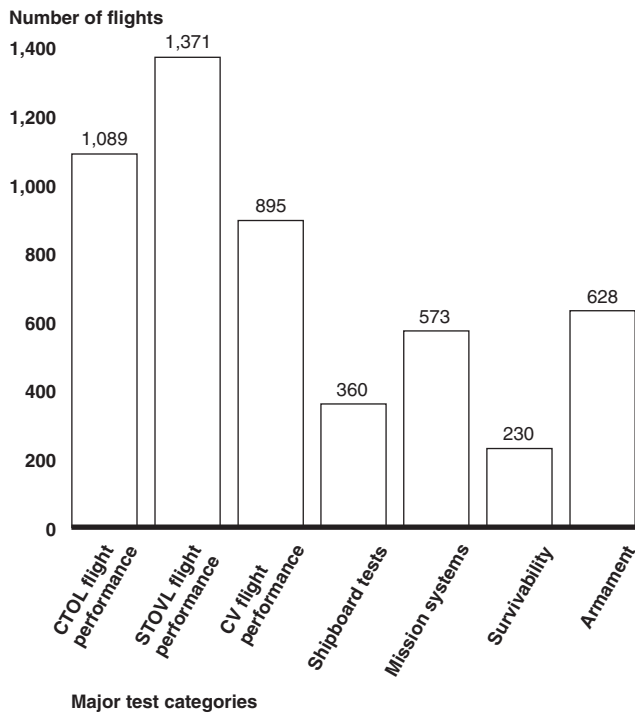
The JSF program's acquisition strategy includes significant challenges to achieve projected cost and schedule goals. The program has begun procurement but not yet demonstrated that the aircraft design is mature, can be manufactured efficiently, and delivered on time. The flight test program has just begun, and there is always risk of problems surfacing and causing further delays. The degree of concurrency between development and production in the JSF program's acquisition strategy still includes significant risks for cost and schedule overruns or late delivery of promised capabilities to the warfighter. The program also faces uncertainties with the amount of funding that will be available to support the program's plan. Other DOD review and oversight organizations have also expressed concern over the level of risk in the program and the resulting costs that will be incurred to complete this acquisition program.

## Challenges to Complete Flight Testing

The program has planned a 7-year flight test program that includes over 11,000 hours of testing and over 6,000 flights. This is 75 percent more than the F-22A's flight test program and more than double the F/A-18E/F testing efforts. As of this report, the flight test program was only beginning with essentially all critical flight testing remaining to confirm that the aircraft

will indeed deliver the required performance. Figure 4 shows the planned flight tests by major test categories.

**Figure 4: Major Areas of JSF Flight Testing to Be Completed**



Source: Lockheed Martin (data), GAO (analysis).

The JSF variants possess significant similarities—all designed to have low observable airframe characteristics, fly at supersonic speeds, shoot air-to-air missiles, and drop bombs on target—but each variant has unique performance goals to support the services’ different operational concepts and environments. Test officials acknowledge that each variant will require separate flight testing to demonstrate that it will fly as intended. About two-thirds of the flight tests are planned for demonstrating the performance of each aircraft design. The other one-third of the flight tests are expected to confirm shipboard operations, mission systems, survivability, and armament.

Manufacturing and technical problems can delay the completion of a flight test program, increase the number of flight test hours needed to verify that the system will work as intended, and affect scheduled delivery to the warfighter. Under the current testing schedule, the JSF program plans to

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manufacture and deliver 15 flight test aircraft and 7 ground test articles in 5 years—an aggressive schedule when compared with other programs with fewer variables. For example, the F-22A program took almost 8 years to manufacture and deliver nine flight test aircraft and two ground test articles of a single aircraft design. When the B-2 program began flight testing in July 1989, it estimated that the flight test program would last approximately 4.5 years and require about 3,600 flight test hours. When the test program ended in 1997, the flight test hours had grown to 5,000 hours, or by 40 percent, over an 8-year period. Program officials cited several causes, including difficulties in manufacturing test aircraft and correcting deficiencies from problems discovered during testing. The F-22A encountered similar delays increasing a planned 4-year flight test program to about 8 years, affecting the program’s ability to conduct operational testing and move into production on schedule. As discussed earlier, current JSF schedules are already showing that delivery of early test aircraft will be later than the planned delivery date.

The flight test program will also hinge on the delivering aircraft with the expected capabilities. JSF’s expected capabilities are largely dependent on software that supports vehicle and mission systems. The program plans to develop over 22 million lines of code—more than 6 times the lines of code needed for the F-22A—in five blocks. The first block is nearly complete and the last block is scheduled for completion in late 2011. The program has completed less than 40 percent of the software needed for the system’s full functionality. Most of the completed software is designed to operate the aircraft’s flying capabilities, while much of the remaining software development includes software needed for mission capability, including weapons integration and the fusion of information from onboard sensors and sources off the aircraft. Past programs have encountered difficulties in developing software, which delayed flight test schedules. JSF program officials acknowledged that the software effort will become particularly challenging during 2007 and 2008 when all five software blocks will be in development at the same time.

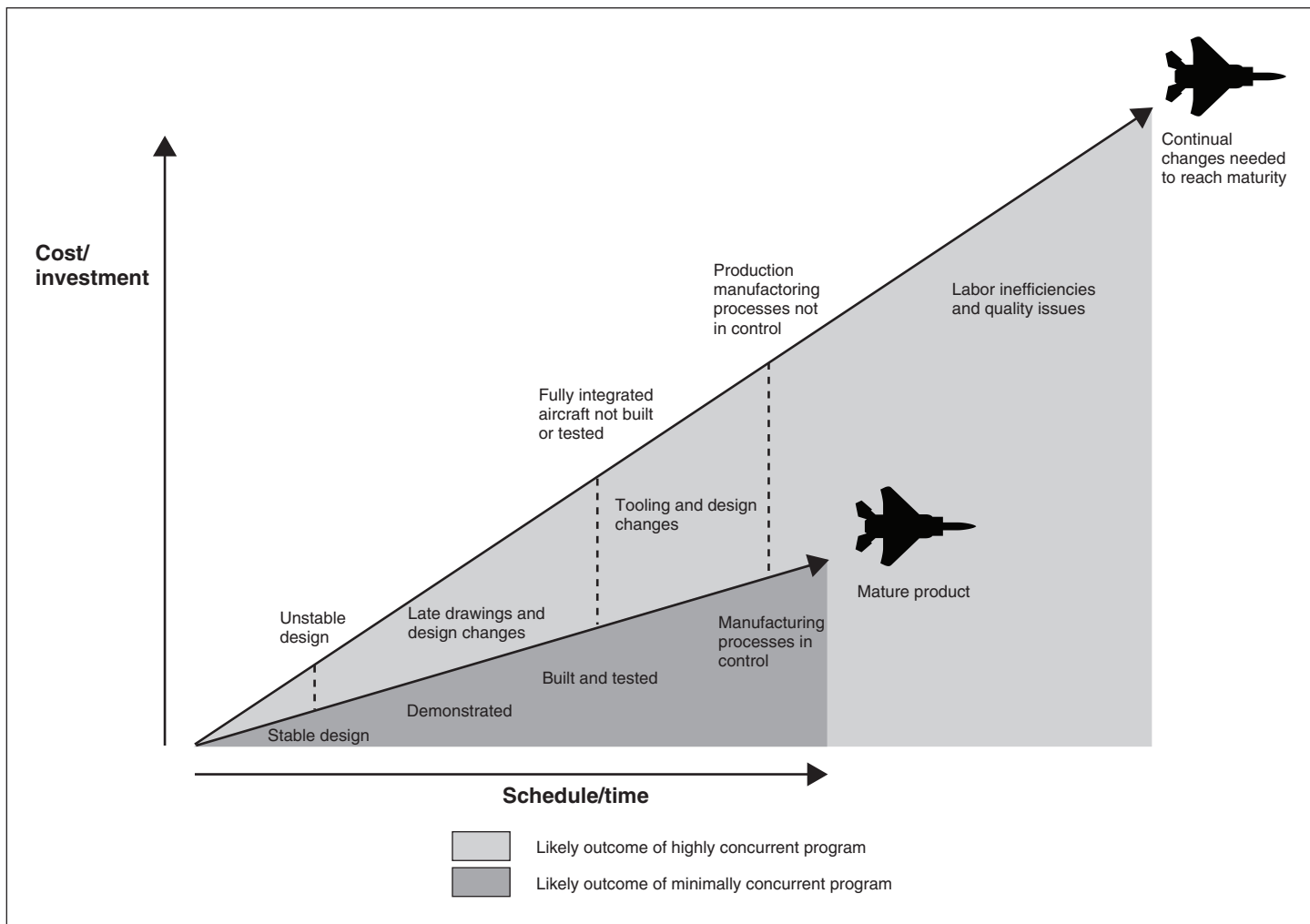
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### Challenges Created by Continued Concurrent Development and Production

The concurrency between development and production in DOD’s acquisition strategy for JSF did not substantially change as a result of the program’s rebaseline in fiscal year 2004. Therefore, the program is entering low-rate initial production without demonstrating through flight testing that (1) the aircraft’s flying qualities function within the parameters of the flight envelope—that is, the set limits for altitude, speed, and angles of attack; (2) the aircraft design is reliable; or (3) a fully integrated and capable aircraft system can perform as intended. Starting production

before ensuring design maturity through flight testing significantly increases the risk because of the of costly design changes that will push the program over budget and behind schedule. Failure to capture key design knowledge before producing aircraft in quantity can lead to problems that eventually cascade and become magnified through the product development and production phases. Figure 5 is a notional illustration showing the impacts that can result from a highly concurrent acquisition strategy to one with less concurrency and that captures key design and manufacturing data before production begins.

**Figure 5: Notional Illustration Showing the Different Paths That JSF Development Can Take**



Source: GAO.

While some concurrency may be beneficial to efficiently transition from the development stage of a program to production, the JSF is currently planned to be significantly more concurrent than the F-22A program that failed to deliver the warfighting capability on time and at predicted costs. Table 4 provides a more detailed comparison between the JSF and F-22A development programs and the accomplishments and requirements before starting production in each program.

**Table 4: Comparison between F-22A and Joint Strike Fighter Development Programs**

	Status of Flight Test Programs at the Start of Low Rate Initial Production		Point When Joint Strike Fighter Will Match Similar F-22A Accomplishments
	F-22A	Joint Strike Fighter	
<b>Flight test program accomplished</b>			
Flight test hours	Approximately 1,300	Approximately 30	2008
Percent of flight test hours	20 percent	Less than 1 percent	2009
Number of flight test aircraft delivered	6 of 9	1 of 15	2009
Months of flight testing	48	3	2010
<b>Key test events accomplished</b>			
Initiated fatigue testing	Yes	No	2008
Initiated separation of weapons testing	Yes	No	2009
Initiated radar cross section testing	Yes	No	2009
Full scale static testing	Yes	No	2009
First flight of fully integrated aircraft	Yes	No	2012

Source: GAO analysis of DOD data.

As a result of the risk associated with highly concurrent development and production, the JSF program plans to place initial production orders on cost reimbursement contracts. Cost reimbursement contracts provide for payment of allowable incurred costs, to the extent prescribed in the contract. Such contracts are used when costs cannot be estimated with sufficient accuracy to use any type of fixed price contract. Cost reimbursement contracts place a substantial risk on the buyer—in this case DOD—because the contractor’s responsibility for the cost risks of performance has been minimized or reduced. As knowledge is gained over time, the program office intended to shift the contract type to one where more cost risk is placed on the contractor. However, DOD materials supporting the President’s fiscal year 2008 budget show that all low rate production orders will be placed on cost reimbursement contracts.

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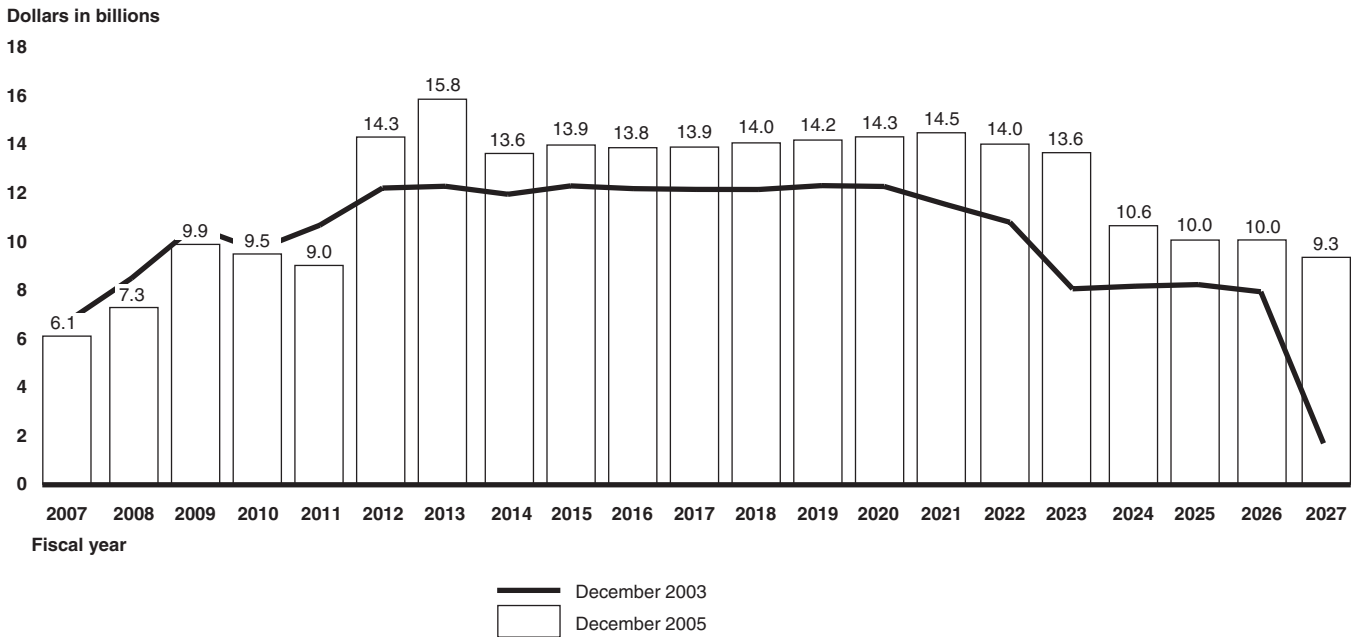
## Unprecedented Funding Requirements Could Challenge Program Execution

To execute its current plan, the JSF program must obtain unprecedented levels of annual funding—on average over \$12.6 billion annually in acquisition funds over the next 2 decades. Regardless of likely increases in program costs, the sizeable continued investment in JSF—estimated at roughly \$252 billion over 20 years—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 achieve current cost and schedule estimates for the revised program baseline. The consequences of an even modest cost increase or schedule delay on a program this size is dramatic. For example, since the program rebaseline in fiscal year 2004, the estimated annual funding requirements have increased every year from 2012 to 2027 by at least \$1 billion and in some cases by \$3 to \$7 billion. These funding increases would be enough to fund several major programs’ activities. Figure 6 shows growth in estimated annual funding requirements from December 2003 to December 2005.



**Figure 6: JSF Program's Annual Funding Requirements**



Source: GAO analysis of DOD data.

Due to affordability pressures, DOD is beginning to reduce procurement budgets and annual quantities. The just-released fiscal year 2008 defense budget shows declining procurement quantities for the first years of production. To meet future constrained acquisition budgets, Air Force and Navy officials and planning documents suggest a decrease in maximum annual buy quantities from 160 shown in the current program of record to about 115 per year, a 28 percent decrease. While this will reduce annual funding requirements, it will also stretch the procurement program at least 7 years to 2034, assuming buy quantities are deferred rather than eliminated.

### DOD Organizations Have Raised Concerns about Program Risks and Estimated Costs

DOD's military service operational test organizations, the Cost Analysis and Improvement Group (CAIG), and the Defense Contract Management Agency (DCMA) have expressed concerns over the level of risk and estimated costs of the program. These oversight and testing organizations highlight some of the program risks and the challenges the JSF program must overcome to avoid further slips in schedule and more cost growth.

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A February 2006 operational assessment of the JSF program by Air Force, Navy and United Kingdom operational test officials noted several areas of risk. According to the test report, several of these issues, if not adequately addressed, are likely to pose substantial or severe operational impact to the JSF's mission capabilities. Key concerns raised in the report include the following:

- Software development and testing schedules are success-oriented and have little margin to accommodate delays.
- Developmental flight test schedule provides little capability to respond to unforeseen problems and still meet scheduled start of operational testing. This threatens to slip operational testing and initial operational capability.
- Predicted maintenance times for propulsion system support, integrated combat turn, and gun removal and installation do not meet requirements.
- Design requirements to preserve volume, power, and cooling for future growth are in jeopardy and will limit capability to meet future requirements.
- Certain technical challenges in the aircraft or its subsystem design that could impact operational capability.

In a follow-up discussion on the report, test officials stated that these concerns were still current and they had not been informed by the program office of planned actions to address them. The December 2006 Annual Report of DOD's Director, Operational Test and Evaluation recommended that the JSF program follow up on these issues.

The CAIG has expressed concerns about the reality of estimated program costs. Its preliminary cost estimate in 2005 was substantially higher than the program office estimate. The CAIG cited costs associated with mission systems, system test, engines, and commonality as drivers in the difference between its estimate and that of the program office. According to discussions in 2006 with CAIG officials, they still have concerns and continue to expect program costs to be much higher than the program office's current estimate. The CAIG is not required to submit its next formal independent cost estimate until the preparations for Milestone C, which for the JSF program is full-rate production. For major defense acquisition programs, this milestone generally should occur before low-rate initial production. Milestone C is scheduled for late 2013.

DCMA's concerns focus on the prime contractor's ability to achieve its cost and schedule estimates. DCMA, responsible for monitoring the prime

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contractor's development and procurement activities, found that delays in aircraft deliveries and critical technical review milestones put at risk the contractor's ability to meet the current schedule. DCMA also identified manufacturing operations as a high-risk area highlighting issues with parts delivery, raw material availability, and subcontractor performance. Finally, it raised concerns with contractor cost growth stating that the contractor has shown continuing and steady increases since development started, even after the contract's target price was increased by \$6 billion as part of the program's rebaseline. As of November 2006, DCMA projects that the contractor's current estimated development costs will increase by about \$1 billion.

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## Conclusions

The JSF is entering its 6th year of a 12-year development program and is also entering production. The development team has achieved first flight and has overcome major design problems found earlier in development. In addition, the department counts on this aircraft to bear the brunt of its recapitalization plans. Therefore, we believe the program is critical to the department's future plans and is viable, given progress made to date. However, the current acquisition strategy still reflects very significant risk that both development and procurement costs will increase and aircraft will take longer to deliver to the warfighter than currently planned. Even as the JSF program enters the mid point of its development, it continues to encounter significant cost overruns and schedule delays because the program has continued to move forward into procurement before it has knowledge that the aircraft's design and manufacturing processes are stable. Although some of the additional costs were predictable, other costs, especially those resulting from rework, represent waste the Department can ill afford.

Flight testing began just a few months before the decision to begin low-rate initial production. The challenges and risks facing the program are only expected to increase as the program begins to ramp up its production capabilities while completing design integration, software design, and testing. DOD's approval to enter low-rate initial production this year committed the program to this high risk strategy. If the program is unable to mitigate risks, its only options will be to reduce program requirements or delay when the program achieves initial operational capability. We see two ways this risk can be reduced: (1) reducing the number of aircraft for procurement before testing demonstrates their performance capabilities, thereby reducing the potential for costly changes to the aircraft and manufacturing processes or (2) reexamining the required capabilities for

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initial variants with an eye toward bringing them up to higher capability in the future.

Last year Congress reduced funding for the first two low-rate production lots of aircraft thereby slowing the ramp up of production. This was a positive first step in lowering risk during the early years of testing. However, a significant amount of ground and flight tests remains over the next 6 years. All three variants need to demonstrate their flight performance. The carrier variant will be the last of the three variants to be delivered to the flight test program. It is now scheduled to start flight testing in May 2009 and has nearly 900 flight tests planned to demonstrate its flight performance. If the program executes its plan for a steep ramp up in production before proving the basic flying qualities of each aircraft variant, the likelihood of costly changes to its significant investment in production will remain high.

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## Recommendation for Executive Action

To improve chances of a successful outcome, we are recommending that the Secretary of Defense limit annual low-rate initial production quantities to no more than 24 aircraft per year, the current manufacturing capacity, until each variant's basic flying qualities have been demonstrated in flight testing now scheduled in the 2010 time frame.

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## Agency Comments and our Evaluation

DOD provided us with written comments on a draft of this report. The comments appear in appendix II.

DOD non-concurred with our recommendation stating that the current JSF acquisition strategy provides an effective balance of technical risk, financial constraints, and operational needs of the services. However, we believe DOD's actions to reduce aircraft quantities in the fiscal year 2008 President's Budget are in line with our recommendation to limit production to current manufacturing capacity until each variant's flying qualities have been demonstrated in flight testing. In the 2008 budget, DOD reduced the number of production aircraft it plans to buy during the flight test program by about 35 percent as compared to its previous plan for the JSF. Under this new plan DOD does not substantially increase its buy quantities of production aircraft until 2011. We continue to believe that limiting production quantities until the design is demonstrated would reduce the overlap in production and development while still allowing the efficient transition from development to production. It would also make cost and schedule more predictable and lessen the risk to DOD's production investment. The JSF program is still only in its sixth year of a

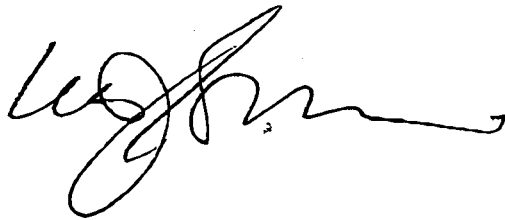
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12-year development program with significant challenges remaining such as completing the design, software development, and flight testing. As such, there is continued risk that testing will not go as planned and demonstrating the aircraft's capability could be delayed beyond the current plan. Therefore, we maintain our recommendation and will continue to monitor the progress in the test program and the resulting dynamics between development and production.

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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 made 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. Contact points for our offices of Congressional Relations and Public Affairs may be found on the last page of this report. Other staff making key contributions to this report were Michael Hazard, Assistant Director; Lily Chin; Matthew Lea; Gary Middleton; Daniel Novillo; Karen Sloan; Brian Smith, Adam Vodraska; and Joe Zamoyta.

A handwritten signature in black ink, appearing to read 'Michael J. Sullivan', with a stylized flourish at the end.

Michael J. Sullivan  
Director  
Acquisition and Sourcing Management

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# Appendix I: Scope and Methodology

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To determine the status of the Joint Strike Fighter (JSF) program's cost, schedule, and performance, we compared current program estimates against estimates established after the program rebaselined in fiscal year 2004. Current official program cost estimates are based on the program's December 31, 2005, Selected Acquisition Report to Congress. At the time of our review, the Office of the Secretary of Defense was still preparing its new cost estimate to be included in the program's Selected Acquisition Report dated December 31, 2006, expected to be delivered to the Congress in April 2007. Because the new official cost estimate for the JSF program will not be available until after this report is issued we are unable to make informed judgments on those estimated costs. It should be noted that after our 2006 report was issued on March 15, 2006, DOD released its December 2005 Selected Acquisition Report, which showed an increase of over \$19 billion in total estimated JSF program costs.

We identified changes in the program's cost, schedule, and performance since the program rebaseline and analyzed relevant information to determine the primary causes of those changes. We reviewed JSF management reports, acquisition plans, test plans, risk assessments, cost reports, independent program assessments, and program status briefings. We interviewed officials from the DOD acquisition program management office and prime contractor to gain their perspectives on the performance of the program.

To identify the challenges the program will face in the future, we compared the program's plans and results to date with future plans to complete development. We analyzed design and manufacturing data from the program office and the prime contractor to evaluate performance and trends. We reviewed program risk reports, earned value management data, and manufacturing data to identify uncertainties and risks to completing the program within the new targets established by the program rebaseline. We analyzed test program and software data to understand the readiness and availability of development aircraft for the test program. We also obtained information on past DOD programs from Selected Acquisition Reports and prior work conducted by GAO over the past two decades. We interviewed officials and reviewed reports from several DOD independent oversight organizations to gain their perspectives on risk in the program.

To assess the likely impacts of concurrently developing and manufacturing JSF aircraft we compared the program's plans and results to date against best practice standards for applying knowledge to support major program investment decisions. The best practice standards are based on a GAO body of work that encompasses 10 years and visits to over 25 major

commercial companies. Our work has shown that valuable lessons can be learned from the commercial sector and can be applied to the development of weapons systems. We identified gaps in product knowledge at the production decision, reasons for these gaps, and the risks to the program. We also examined the F-22A program's acquisition approach. We interviewed officials from the DOD acquisition program management office and prime contractor to gain their perspectives on program risks and their approaches to managing risks.

In performing our work, we obtained information and interviewed officials from the JSF Joint Program Office, Arlington, Virginia; F-22A Program Office, Wright-Patterson Air Force Base, Ohio; Lockheed Martin Aeronautics, Fort Worth, Texas; Defense Contract Management Agency, Fort Worth, Texas; and offices of the Director, Operational Test and Evaluation, and Acquisition, Technology and Logistics, Program Analysis and Evaluation-Cost Analysis Improvement Group, which are part of the Office of Secretary of Defense in Washington, D.C. We performed our work from June of 2006 to March of 2007 in accordance with generally accepted government auditing standards.



# Appendix II: Comments from the Department of Defense



ACQUISITION,  
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OFFICE OF THE UNDER SECRETARY OF DEFENSE  
3000 DEFENSE PENTAGON  
WASHINGTON, DC 20301-3000

MAR 5 2007

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 response to the Government Accountability Office (GAO) draft report 07-360, "JOINT STRIKE FIGHTER: Progress Made and Challenges Remain," dated January 26, 2007 (GAO Code 120570). The Department non-concurs with the report recommendation, but appreciates the GAO's highlighting of both program successes and challenges. Details of the non-concurrence are contained in the enclosure.

The Department values the opportunity to comment on the draft report and looks forward to continued discussions on the program with the GAO.

Sincerely,

A handwritten signature in black ink, appearing to read "David G. Ahern".

David G. Ahern  
Director  
Portfolio Systems Acquisition

Enclosure:  
As stated



GAO DRAFT REPORT – DATED JANUARY 26, 2007  
GAO-07-360

“JOINT STRIKE FIGHTER – Progress Made and Challenges Remain”

DEPARTMENT OF DEFENSE COMMENTS  
TO THE RECOMMENDATION

**RECOMMENDATION:** To improve chances for a successful outcome, the GAO recommends the Secretary of Defense limit annual production quantities to no more than 24 aircraft per year, the current manufacturing capability, until each variant’s basic flying qualities have been demonstrated in flight testing now scheduled in the 2010 timeframe.

**DOD Response:** Non-concur. The current F-35 acquisition strategy provides the most effective balance of technical risk, financial constraints and the Services’ operational needs. Fiscal constraints have driven the DoD’s decision to reduce near-term quantities in the FY08 President’s Budget. However, the program will continue to ramp up production rate, tooling, and support activities to meet operational needs. The program has an acceptable level of concurrency and an appropriate acquisition strategy. Eight international partners have also recently reasserted their confidence in the F-35 acquisition strategy by signing the Production, Sustainment and Follow-on Development Memorandum of Understanding (MOU).

The Department believes that a major manufacturing or design flaw, requiring extensive delay of the program, is unlikely. Furthermore, that risk is more than offset by the certainty of higher unit costs which the Department would incur if it accepted a lower ramp rate. The Department would also need to further extend legacy fleets past their current service life expectancies, including higher operating costs which would consume funds currently targeted for recapitalization/ modernization efforts. Allied Services committed to this program and would be similarly impacted. The Department believes that restricting F-35 annual production quantities as recommended by the GAO would further increase F-35 procurement costs, outpacing any potential retrofit costs to correct any future design deficiencies.

Modern experience with both commercial and military aircraft supports the Department’s position. The F-35 employs extensive use of modern digital design and development tools, ground test laboratories, modeling and simulation techniques and flying test beds to accelerate design maturation and burn-down development risk far ahead of flight test. The Department’s confidence has been reinforced with the design, manufacturing, and flight test performance of the first F-35 flight test aircraft. Numerous other indicators from this aircraft--for example, actual weight within 1% of predicted, no fuel leaks during ground tests (unprecedented), high level of quality in manufacturing and assembly, and a high frequency of flight tests thus far--further increase Department confidence. The program is supported by thorough insight by the engineering expertise of the Navy and Air Force, and further reinforced by the outstanding data correlation between initial flight test

results and modeling and simulation predictions. Similar experiences have been seen in the commercial sector, where both the Boeing 777 and 787 had virtual “roll-outs” and successfully adopted concurrent development and production strategies.

The FY08 President’s Budget Request proposes near-term reductions in the quantities of F-35s to be procured over the next five years, due to shortfalls in outyear Service funding (FY12 and FY13) and procurement and developmental cost growth in the program. A significant portion of the procurement cost growth cited by GAO is due to inflation factors, aggregate aerospace company financial performance, and the worldwide precious metals commodities market—aspects that the F-35 program could not accurately project. The Department continues to monitor program performance and incentivize the contractor to keep unit costs in check. The Department will continue to hold annual Defense Acquisition Boards with stringent exit criteria before committing to further procurement investments.

The Department agrees with several other concerns that the GAO identifies:

- The planned flight test activity does not yet fit within the development schedule. The program has undertaken an intensive review of its verification strategy in order to reduce the number of flight tests without sacrificing the level of fidelity needed to verify performance.
- Software and integration is a challenge in 2007 and 2008. The Department will closely track software productivity and frequently revisit its assumptions about how many lines of code it can execute with the dollars and schedule remaining. Warfighter representatives are heavily involved in making the difficult trades, which will be critical to produce the most capable aircraft within these constraints.
- Executing the remaining design tasks within the planned labor profile to meet the planned manufacturing dates will also be a challenge. The program has recently completed extensive productivity improvement plans and developed more efficient manufacturing and design processes. These will be watched closely in 2007 to ensure development costs do not spiral upwards.

The Department is pleased that the GAO recognized the F-35 program’s progress. Specifically, the report appropriately assesses the F-35 program’s performance from its current baseline. The report recognizes some of the many steps the program office and contractor have taken to be responsive to problems to date. Finally, it acknowledges that some program concurrency is helpful in making the transition from development to production, and that the program is viable given progress to-date.

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