United States Government Accountability Office

GAO

Report to Congressional Committees

March 2008

JOINT STRIKE FIGHTER

Recent Decisions by DOD Add to Program Risks

GAO-08-388

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Highlights

Highlights of GAO-08-388, a report to Congressional Committees

Why GAO Did This Study

The Joint Strike Fighter (JSF) program seeks to produce and field three aircraft variants for the Air Force, Navy, Marine Corps, and eight international partners. The estimated total investment for JSF now approaches $1 trillion to acquire and maintain 2,458 aircraft.

Under congressional mandate, GAO has annually reviewed the JSF program since 2005. GAO's prior reviews have identified a number of issues and recommended actions for reducing risks and improving the program's outcomes.

This report, the fourth under the mandate, focuses on the program's progress in meeting cost, schedule, and performance goals; plans and risks in development and test activities; the program's cost-estimating methods; and future challenges facing the program.

To conduct its work, GAO identified changes in cost and schedule from prior years and their causes, evaluated development progress and plans, assessed cost-estimating methodologies against best practices, and analyzed future budget requirements.

What GAO Recommends

GAO recommends that DOD revisit and, if appropriate, revise the Mid-Course Risk Reduction Plan to address concerns about testing, use of management reserves, and manufacturing. GAO also recommends action to improve the reliability and fidelity of the JSF cost estimate. DOD substantially agreed.

To view the full product, including the scope and methodology, click on GAO-08-388. For more information, contact Michael J. Sullivan (202) 512-4841 or sullivanm@gao.gov.

What GAO Found

Since last year's report, the JSF program office estimates that total acquisition costs increased by more than $23 billion, primarily because of higher estimated procurement costs. The JSF development cost estimate stayed about the same. Development costs were held constant by reducing requirements, eliminating the alternate engine program, and spending management reserve faster than budgeted. Facing a probable contract cost overrun, DOD implemented a Mid-Course Risk Reduction Plan to replenish management reserves from about $400 million to about $1 billion by reducing test resources. Progress has been reported in several important areas, including partner agreements, first flights of a JSF prototype and test bed, and a more realistic procurement schedule.

The midcourse plan carries the risk of design and performance problems not being discovered until late in the operational testing and production phases, when it is significantly more costly to address such problems. The plan also fails to address the production and schedule concerns that depleted management reserves. Cost and schedule pressures are mounting. Two-thirds of budgeted funding for JSF development has been spent, but only about one-half of the work has been completed. The contractor is on its third, soon to be fourth, manufacturing schedule, but test aircraft in manufacturing are still behind, the continuing impacts of late designs, delayed delivery of parts, and manufacturing inefficiencies.

We believe that JSF costs will likely be much higher than reported. The estimates do not include all costs, including about $6.8 billion for the alternate engine program. In addition, some assumptions are overly optimistic and not well documented. Three independent defense offices separately concluded that program cost estimates are understated by as much as $38 billion and that the development schedule is likely to slip from 12 to 27 months. Discrepancies in cost estimates add to program risks and hinder congressional oversight. Even so, DOD does not plan for another fully documented, independent total program life-cycle cost estimate until 2013.

As JSF finalizes the three designs, matures manufacturing processes, conducts flight tests, and ramps up production, it faces significant challenges. JSF's goal—to develop and field an affordable, highly common family of strike aircraft—is threatened by rising unit procurement prices and lower commonality than expected. The program also makes unprecedented funding demands—an average of $11 billion annually for two decades—and must compete with other defense and nondefense priorities for the shrinking federal discretionary dollar. Further, expected cost per flight hour now exceeds that of the F-16 legacy fighter, one of the aircraft it is intended to replace. With almost 90 percent (in terms of dollars) of the acquisition program still ahead, it is important to address these challenges, effectively manage future risks, and move forward with a successful program that meets our and our allies' needs.

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Abbreviations:

CAIG	Cost Analysis Improvement Group
CTOL	conventional takeoff and landing
CV	carrier-suitable variant
DCMA	Defense Contract Management Agency
DOD	Department of Defense
EVM	earned value management
JSF	Joint Strike Fighter
IOT&E	Initial Operational Test and Evaluation
NAVAIR	Naval Air Systems Command
OSD	Office of the Secretary of Defense
SAR	Selected Acquisition Report
STOVL	short takeoff and vertical landing

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United States Government Accountability Office
Washington, DC 20548

March 11, 2008

Congressional Committees

The Joint Strike Fighter (JSF) is Department of Defense's (DOD) most complex and ambitious aircraft acquisition, seeking to simultaneously produce and field three aircraft variants for the Air Force, Navy, Marine Corps, and eight international partners. For the United States, the JSF will need a joint, long-term commitment to very large annual funding requirements and a total investment now approaching $1 trillion dollars—$300 billion to acquire 2,458 aircraft and $650 billion in life-cycle operation and support costs, according to official program estimates. The JSF is critical to our nation's plans for recapitalizing tactical aircraft and just as important to our allies.

The Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 requires GAO to review the JSF program annually for five years.[1] Previous reports identified opportunities for the program to reduce risks and improve the chance for more successful outcomes. We have expressed concern about the substantial overlap of development, test, and production activities and recommended a more evolutionary and knowledge-based acquisition strategy with limited investment in production aircraft until each variant demonstrates required capabilities in flight testing.[2] This is the fourth report under the mandate in which we (1) determine the JSF program's progress in meeting cost, schedule, and performance goals; (2) assess plans and risks in development and test activities; (3) evaluate program office cost-estimating methodology; and (4) identify future challenges facing the program.

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. While we were provided sufficient information to make the

[1] Pub. L. No. 108-375, § 213 (2004).

[2] GAO, *Joint Strike Fighter: Progress Made and Challenges Remain*, GAO-07-360 (Washington, D.C.: Mar. 15, 2007); *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).

assessments contained in this report, a continuing concern has been the currency of cost and schedule data. The data we are reporting here are from the JSF Selected Acquisition Report (SAR) dated December 2006 that was released to Congress and us in April 2007. That SAR reflects the program position at the time of the submission of the fiscal year 2008 President's Budget. We were not able to review the program office's updated estimates associated with the fiscal year 2009 budget, which will be reported in the new December 2007 SAR to be released in April 2008. The program office declined to provide updated costs, stating that those figures are sensitive because the new budget request had not been finalized at the time of our review. Every year, this timing disconnect results in us reporting soon-to-be-outdated cost and schedule data. For example, shortly after our last report was issued on March 15, 2007, DOD released new cost estimates that disclosed an increase of more than $23 billion in JSF program costs. On the basis of the evidence we do have and our analysis, we fully expect future cost estimates to be substantially higher than the program estimates in this report.

To conduct this work, we tracked and compared current cost and schedule estimates with those of prior years, identified major changes, and determined causes. We obtained earned value data, contractor workload statistics, performance indicators, and manufacturing results. We assessed the program office's cost estimating methodologies against best practices prescribed in GAO's *Cost Assessment Guide*. We discussed results to date, plans, and future challenges with DOD and contractor officials. We conducted this performance audit from June 2007 to March 2008 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Results in Brief

The JSF total acquisition cost estimate increased by more than $23 billion since our March 2007 report due to changes in procurement costs. Principal driving factors were (1) increased unit costs from extending the procurement period seven years at lower annual rates and (2) increased future price estimates based on contractor proposals for the first production lot. The official cost estimate for development remained about the same in total as it has since the program was restructured in 2004. However, this was largely achieved by reducing requirements, not fully funding the alternate engine program despite congressional interest in the

program, and spending management reserves much faster than budgeted. Facing a probable contract cost overrun, DOD officials decided not to request additional funding and time for development, opting instead to reduce test resources in order to replenish management reserves from $400 million to $1 billion. During the last year, DOD and the contractor also reported progress in several important areas, including international partner agreements, first flights of a JSF prototype and test bed, and a more realistic procurement schedule.

The recent decision to replenish management reserves by reducing test resources, known as the Mid-Course Risk Reduction Plan, significantly increases the risks of not completing development testing on time and not finding and fixing design and performance problems until late into operational testing and production, when it is more expensive and disruptive to do so. The plan also does not directly address and correct the continuing production and schedule concerns that depleted management reserves. We expect program development and procurement costs to increase substantially and schedule pressures to worsen based on performance to date and the conditions that gave rise to the risk reduction plan. Two-thirds of budgeted funding for the JSF has been spent on the prime development contract, but only about one-half of the work has been completed. The contractor has extended manufacturing schedules several times, but test aircraft delivery dates continue to slip. The flight test program has barely begun, but faces substantial risks with reduced assets as design and manufacturing problems continue to cause delays that further compress the time available to complete development. The Director, Operational Test and Evaluation, and several other prominent defense offices objected to the midcourse plan as too risky because it does not provide adequate resources for development testing or resolve systemic problems that depleted management reserves. We agree.

We do not think the program cost estimate is reliable when judged against cost estimate standards used throughout the federal government and industry. Specifically, the program cost estimate (1) is not comprehensive because it does not include all applicable costs, including $6.8 billion for the alternate engine program; (2) is not accurate because some of its assumptions are overly optimistic and not supportable—such as applying a weight growth factor only half as large as historical experience on similar aircraft—and because the data system relied upon by the prime contractor and the program office to report and manage JSF costs and schedule is deficient; (3) is not well documented in that it does not sufficiently identify to cost analysts the primary methods, calculations, results, rationales and assumptions, and data sources used to generate

cost estimates; and (4) is not credible according to three independent defense offices who all conclude that program cost estimates are understated by as much as $38 billion and that the development schedule is likely to slip from 12 to 27 months. Despite this and all the significant events and changes that have occurred in the 6 years since the start of system development, DOD does not intend to accomplish another fully documented, independent total program life-cycle cost estimate for another 6 years.

The JSF is entering its most challenging phase as it finalizes three designs, matures manufacturing processes, conducts flight tests, and ramps up production. The first and foremost challenge is affordability. From its outset, the JSF goal was to develop and field an affordable, highly common family of strike aircraft. That goal is threatened by rising unit procurement prices and somewhat lower commonality than expected, raising concerns that the United States and its allies may not be able to buy as many aircraft as currently planned. The program also makes unprecedented demands for funding from the defense budget—an annual average of about $11 billion for the next two decades—and must compete with other defense and non-defense priorities for the shrinking federal discretionary dollar. Further, informed by more knowledge as the program progresses, DOD doubled its projection of JSF life-cycle operating and support costs compared to last year's estimate and its expected cost per flight hour now exceeds that of the F-16 legacy fighter it is intended to replace. With almost 90 percent (in terms of dollars) of the acquisition program still ahead, it is important to address these challenges, effectively manage future risks, and move forward with a successful program that meets our and our allies' needs.

Because of the elevated risks and valid objections raised by the test community and other DOD offices, we recommend that DOD revisit and, if appropriate, revise the Mid-Course Risk Reduction plan recently approved. DOD should specifically address concerns about constrained testing capacity, the integration of flight and ground tests, depletion of management reserves, slippage in the manufacturing schedule, and progress made in correcting deficiencies in the contractor's earned value management system, and to examine in depth the alternatives to the current plan that could reduce risks. To enhance congressional oversight and provide DOD management with a higher-fidelity and more comprehensive cost estimate, we also make several recommendations to improve cost estimates, in particular that DOD accomplish this year a new total program life-cycle cost estimate, validated by the Cost Analysis

Improvement Group, that includes risk analysis and meets DOD policy requirements for major system cost estimates at milestones.

DOD substantially agreed with our recommendations. DOD believes that the midcourse plan is a cost-effective approach with a manageable level of risk that will be monitored and revised if necessary. Regarding our three recommendations on cost estimating, DOD indicated that it will implement all elements except the risk and uncertainty analysis that it believes is not warranted. We think that risk and uncertainty analysis is an important tool that establishes a confidence interval for a range of possible costs—as opposed to a single-point estimate—and facilitates good management decisions and oversight. Such analysis is a best practice in our *Cost Assessment Guide* and we note that OSD's Cost Analysis Improvement Group supports and uses this cost-estimating tool.

Background

The JSF program goals are to develop and field an affordable, highly common family of stealthy, next-generation strike fighter aircraft for the Navy, Air Force, Marine Corps, and U.S. allies. The JSF family consists of three variants. The conventional takeoff and landing (CTOL) variant will primarily be an air-to-ground replacement for the Air Force's F-16 Falcon and the A-10 Warthog aircraft, and will complement the F-22A Raptor. The short takeoff and vertical landing (STOVL) variant will be a multirole strike fighter to replace the Marine Corps' F/A-18C/D and AV-8B Harrier aircraft. The carrier-suitable (CV) variant will provide the Navy a multi-role, stealthy strike aircraft to complement the F/A-18E/F Super Hornet. DOD is planning to buy a total of 2,458 JSFs. The F-35 JSF was christened Lightning II in July 2006.

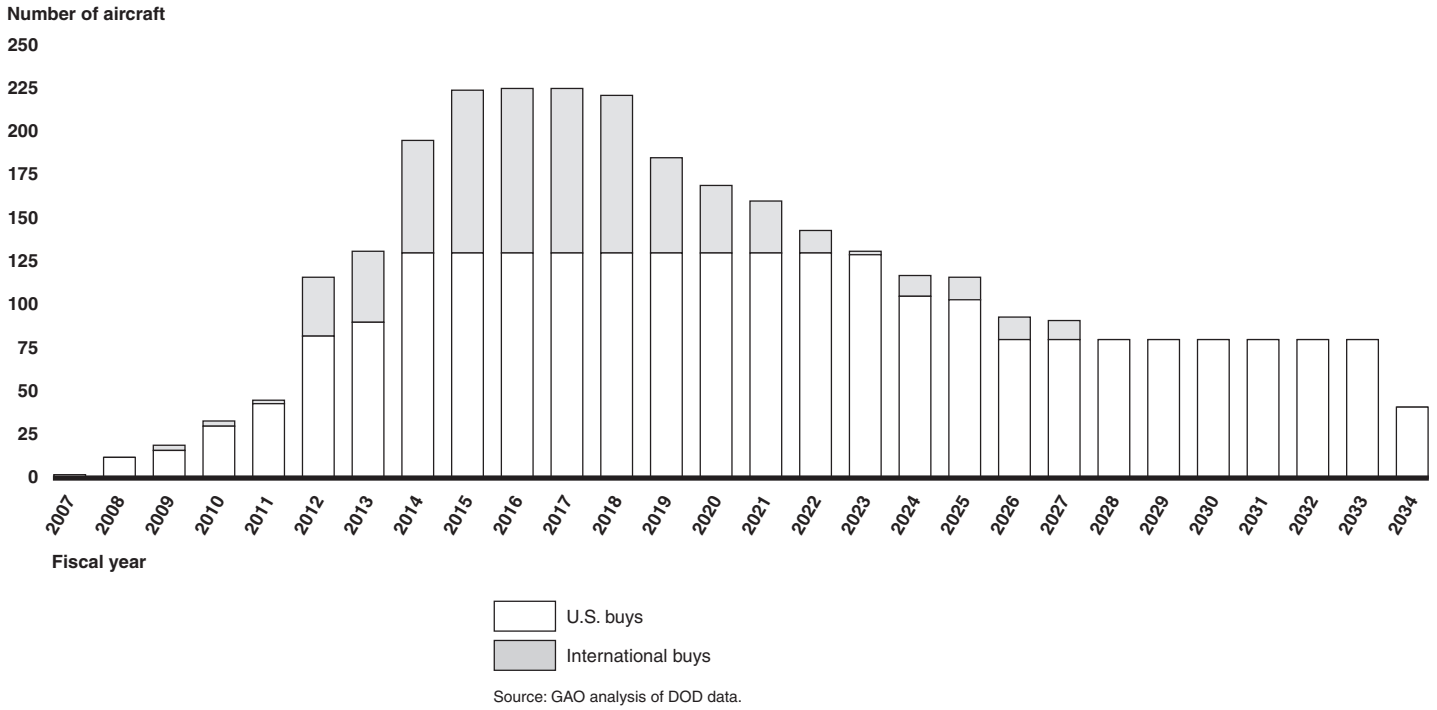
Because of the program's sheer size and the numbers of aircraft it will replace, the JSF is the linchpin of DOD's long-term plan to modernize tactical air forces. It is DOD's largest acquisition program, with total cost currently estimated at $300 billion; the longest in planned duration, with procurement projected through 2034; and the largest cooperative international development program.[3] Our international partners are providing about $4.8 billion toward development, and foreign firms are

[3] The international partners are the United Kingdom, Italy, the Netherlands, Turkey, Canada, Australia, Denmark, and Norway. These nations are contributing funds for system development and have signed agreements to procure a minimum of 646 aircraft. Israel and Singapore are security cooperation participants, and several other nations have reportedly expressed interest in acquiring aircraft.

part of the industrial base producing aircraft. They are expecting to procure a minimum of 646 CTOL and STOVL JSFs. DOD's funding requirements for the JSF assume the benefits in reduced unit costs from these purchases.

Figure 1 shows the JSF's current procurement profile for U.S. and international partners. Partner purchases begin in 2009 and reach a maximum of 95 per year in fiscal year 2016. Total expected procurement in that peak year, including U.S. quantities, is 225 aircraft.

Figure 1: JSF Annual Procurement Plans for the United States and International Partners



Source: GAO analysis of DOD data.

The JSF is a single-seat, single-engine aircraft, designed to rapidly transition between air-to-ground 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. In several ways, JSF development is also more complex and challenging than the F-22A Raptor

and F/A-18E/F Super Hornet programs, the other two contemporary aircraft that DOD is acquiring with JSF to recapitalize tactical air forces. The JSF program is simultaneously developing several airframes and engines for multiple customers and is projected to have significantly more lines of operational flight plan software code than the other aircraft.

The JSF 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. The program entered system development and demonstration in October 2001. At that time, officials planned on a 10½ years development period costing about $34 billion (amount includes costs of about $4 billion incurred before system development start). By 2003, system integration efforts and a preliminary design review revealed significant airframe weight problems that affected the aircraft's ability to meet key performance requirements. Weight reduction efforts were ultimately successful but added substantially to program cost and schedule estimates. In March 2004, DOD rebaselined the program (2004 Replan), extending development by 18 months and adding $7.5 billion to development costs. 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 risks and mature designs.

Progress Measured against Cost, Schedule, and Performance Goals Was Mixed over the Last Year

The total program acquisition cost estimate by the JSF program office has increased since our report last year, primarily due to higher projected procurement unit prices. The reported schedule for major events showed mostly minor slips. Engineering analyses continue to show performance requirements are met, but flight and ground tests planned through 2013 will be necessary to confirm these assessments. DOD and the contractor reported progress in several areas, including international partner agreements, first flights of a JSF prototype and test bed, and a more realistic procurement schedule.

The Program Cost Estimate Increased, while Schedule and Performance Estimates Remained about the Same

JSF costs increased since last year. Table 1 shows the evolution of cost, quantity, and delivery estimates from the initiation of system development, through the 2004 Replan, to the latest data available. It demonstrates the impacts of higher procurement costs on unit costs and schedule delays on the delivery of promised capabilities to the warfighters.

Table 1: Changes in Reported JSF Program Costs, Quantities, and Deliveries

	October 2001 (system development start)	December 2003[a] (2004 Replan)	December 2005[a]	December 2006[a] (latest available data)
Expected quantities				
Development quantities	14	14	15	15[b]
Procurement quantities (U.S. only)	2,852	2,443	2,443	2,443
Total quantities	**2,866**	**2,457**	**2,458**	**2,458**
Cost Estimates (then-year dollars in billions)				
Development	$34.4	$44.8	$44.5	$44.2
Procurement	196.6	199.8	231.7	255.1
Military construction[c]	2.0	0.2	0.2	0.5
Total program acquisition	**$233.0**	**$244.8**	**$276.5**	**$299.8**
Unit Cost Estimates (then-year dollars in millions)				
Program acquisition	$81	$100	$112	$122
Average procurement	69	82	95	104
Estimated delivery dates				
First operational aircraft delivery	2008	2009	2009	2010
Initial operational capability	2010-2012	2012-2013	2012-2013	2012-2015

Source: GAO analysis of DOD data.

[a]Data are from the annual Selected Acquisition Reports that are dated in December but not officially released until March or April of the following year. The December 2003 data reflect the 2004 Replan. The December 2006 data are the latest information on total program costs made available to us by DOD.

[b]A subsequent decision by DOD in September 2007 has reduced development test aircraft by 2 to 13.

[c]Military construction costs have not been fully established and the reporting basis changed over time in these DOD reports. The amount shown for December 2006 represents costs currently in the 2008 future years defense plan.

The current estimate for procurement costs, dated December 2006, shows an increase of $23.4 billion (plus 10 percent) from the estimate of a year earlier and a total of $55.3 billion more (plus 28 percent) since 2004.[4]

[4] To eliminate the effects of inflation, these procurement cost increases expressed in base year fiscal year 2002 dollars are $7.8 billion (plus 5 percent) and $19.6 billion (plus 13 percent), respectively.

Procurement cost increases were primarily due to (1) extending the procurement period seven years at lower annual rates, (2) increased future price estimates based on contractor proposals for the first production lot, (3) airframe material cost increases, and (4) increases resulting from design maturation. Offsetting a portion of the procurement cost increases were lower estimates for labor rates and subcontractor costs.

The official development cost estimate has remained relatively constant since the 2004 Replan. However, there were significant changes in scope and planned use of funds in order to maintain that estimate as officials reduced requirements, did not include full funding for the alternate engine program despite congressional interest in the program,[5] and spent management reserves much faster than budgeted. Management reserves are a pool of money set aside—in this case about 10 percent of the development contract value remaining—to handle unanticipated changes and other risks encountered as a development program proceeds. Weight growth early in development and subsequent problems resulting from late aircraft design changes and subsequent manufacturing inefficiencies depleted reserve funds to an untenable level by 2007. The program faced a probable contract overrun. DOD officials opted not to request additional funding and time to complete development and instead adopted a controversial plan that reduced budgeted funds for development test aircraft and flight plans in order to replenish management reserves from $400 million to about $1 billion, an amount deemed prudent to complete the development phase on time. This plan, known as the Mid-Course Risk Reduction plan, is discussed in more detail later in this report.

Reported schedule slips for key events since last year's report were minor for the most part, but schedules could worsen considerably if the delays in maturing the aircraft and engine designs and manufacturing test aircraft continue to push work effort into later years. This would further compress the time available to complete development and test efforts, affecting the scheduled start of initial operational test and evaluation and the full-rate production decision, and increasing the risk of further delivery delays. The CV's critical design review, the last of three design reviews for the program, occurred in June 2007, seven months later than had been expected. The initial operational capability date for this variant was

[5] Congress has subsequently required that DOD obligate and expend sufficient annual amounts for the continued development and procurement of the alternate engine program. National Defense Authorization Act for Fiscal Year 2008, Pub. L. No. 110-181, § 213 (2008).

pushed out two years to March 2015, to provide more time to mature design and test this variant in the demanding carrier environment. The carrier variant is the least developed of the three, incorporates larger wings, is heavier, and has different speed and range performance requirements than the other two variants.

On the basis of engineering analyses and computer modeling, the JSF program projects that the aircraft design will meet seven of the eight key performance parameters by the end of development. The aircraft is currently not meeting the interoperability parameter, but this depends on capabilities being developed outside the JSF program. Key performance parameters will be verified during ground and flight testing from 2010 to 2013.

Progress Was Made This Year in Several Important Areas

DOD and the contractor made solid progress this year in several areas that could establish a foundation to spur future successes. With almost 90 percent (in terms of dollars) of the acquisition program still ahead, these and other improvements could be leveraged to help better meet cost, schedule and performance goals.

- In February 2007, the United States and eight international partners signed the Production, Sustainment, and Follow-on Development Memorandum of Understanding, committing to purchase aircraft and continuing joint development activities.

- DOD reduced near-term procurement quantities and the rate of ramp-up to full rate production. These actions somewhat lessened the concurrency of development and production we have previously cited and make for a more achievable schedule.

- The prime contractor and major subcontractors continued to implement advanced design and development techniques and utilize extensive computer modeling and simulation in innovative ways for design, test, and integration activities.

- DOD and contractor officials also made good progress toward refining system capabilities, including establishing mission software requirements, with the goal of improving future program executability while still meeting warfighter requirements.

- First flights of the prototype test aircraft and a flying test bed occurred in fiscal year 2007. Both are viewed as important risk reducers in the

test program and initial flights provided valuable and useful information, according to program and contractor officials.

- All test aircraft were in manufacturing during 2007. Low-rate initial production of the first two production aircraft and advance buys for the second production lot also got under way.

Development Program Faces Increased Risks of Further Cost Increases and More Schedule Delays

Late in 2007, DOD officials approved a risky and controversial plan that replenishes management reserves by reducing development test aircraft and test flights in order to stay within current cost and schedule estimates. Difficulties in stabilizing aircraft designs and inefficient production of test aircraft resulted in spending management reserves faster than anticipated. The flight test program has barely begun, but faces substantial risks with reduced assets as delays in design and manufacturing continue to further compress the time available to complete development work prior to operational testing and to support the full-rate production decision. The JSF program is halfway to its planned completion, but is behind schedule and over cost. On the basis of evidence we have gathered, development costs can be expected to increase substantially from the current reported program estimate, and the time needed to complete development testing and subsequent initial operational testing will likely need to be extended, delaying the full-rate production decision now planned for October 2013.

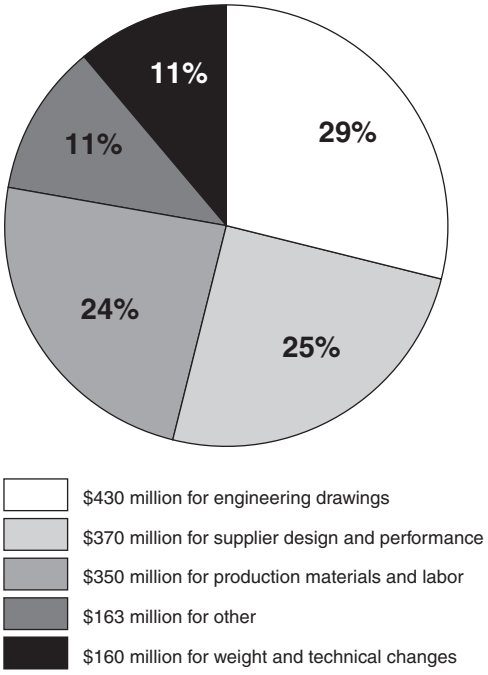
Plan to Address Management Reserve Depletion Adds Risk to the JSF Development Effort

The Office of the Secretary of Defense (OSD) approved the Mid-Course Risk Reduction plan in September 2007. The plan reduces development test aircraft and test flights, and accelerates the reduction of the contractor's development workforce in order to restore management reserves to the level considered prudent to complete the development contract as planned and within the current cost estimate. The test community and others within DOD believe the plan puts the development flight program at considerable risk and trades known cost risk today for unknown cost and schedule risk in the future.

Management reserves are budgeted funds set aside for unanticipated development challenges and increase a program's capacity to deal with unknowns. At development start, JSF budgeted reserves at 10 percent of contract value and expected to draw on them at about the same rate as contract execution. However, the program has had to use these funds much faster than expected to pay for persistent development cost increases and schedule delays. A combination of factors contributed to this problem, such as late release of engineering drawings, production

taking longer than planned, and late delivery of parts from suppliers. In turn, these contributed to continuing cost and schedule impacts in the manufacture of development test aircraft, including extensive and inefficient out-of-station work and delays in proving out the production schedule. Figure 2 shows how management reserves totaling almost $1.4 billion have been depleted since the 2004 Replan.

Figure 2: JSF's Use of Management Reserves



Source: GAO analysis of DOD data.

By mid-2007, the development program had completed one-half of the amount of work scheduled, but had expended two-thirds of the budget. Management reserves had shrunk to about $400 million, less than one-half the amount officials believed necessary to complete the final 6 years of development. At the same time, the program faced significant manufacturing and software integration challenges, costly flight testing, and $950 million in other known cost risks. This presented the program with a likely untenable contract overrun sometime in 2008 if no action was taken. JSF program management identified a continuing persistent cost variance of $250 million to $300 million in the aircraft development contract and the associated shortfall in reserves that required near-term action beyond "belt tightening."

An overarching integrated product team considered several alternative actions, including doing nothing and adding funds from procurement, but the team chair concluded that replenishment of the management reserve was essential to position the JSF program to successfully address its anticipated future development challenges. This option, dubbed the Mid-Course Risk Reduction Plan, removed two development aircraft (one CTOL and one CV), eliminated approximately 850 test flights from the current test plan, revised the verification strategy, increased the use of ground test labs and the flying test bed, and maximized the number of test points to be accomplished during test flights. The plan also accelerated reductions in contractor staff and took other actions. In total, these planned actions are expected to add between $470 million and $650 million into the reserve to recapitalize it to about $1 billion, an amount officials believe will be needed to complete development. Officials intend to use reserves to recover cost and schedule losses in manufacturing and to cover additional future needs.

This plan was subsequently approved by OSD, although serious risks were acknowledged and the team was divided on whether the added risks outweighed the intended benefit. Those in favor of the plan believed that actions were urgently needed to fix the funding imbalance and avoid a contract overrun. In this view, the plan would serve as a stopgap measure to delay another program restructure until more program knowledge and a clearer understanding of future cost requirements were gained.

Officials from several defense offices thought the risks to testing were too great and that the plan did not address the underlying design and manufacturing problems. The Director, Operational Test and Evaluation, identified specific risks associated with the revised test verification strategy and recommended against deleting the aircraft, citing inadequate capacity to handle the pace of mission testing, and for ship suitability, signature testing, and suitability evaluations. This increased the likelihood of not finding and resolving critical design deficiencies until operational testing, when it is more costly and disruptive to do so. OSD's Systems and Software Engineering office concurred, expressed concerns that the plan did not treat the root causes of ongoing production problems, and doubted that the contractor schedule was achievable. The Cost Analysis Improvement Group and others agreed that there was too much risk in reducing test assets at this time since no production representative variant had started flight tests and no analysis of the management reserve depletion had been completed. In summary, the plan trades known cost risk today for unknown cost and schedule risk in the future.

Manufacturing Inefficiencies Continue to Increase Costs and Delay the Production of Development Aircraft

According to our analysis of available evidence, manufacturing test aircraft continue to run behind schedule. The prime contractor has revised the test aircraft manufacturing schedule three times, resulting in slips of up to 16 months in first flight dates of test aircraft. To date, about 3 months of progress has been made for every 4 months of effort. As officials for now have decided not to extend the development period and delay operational tests and full-rate production, this inefficiency increases risk and further compresses time and assets available to complete test activities.

Repercussions from the late release of engineering drawings, design changes, and parts shortages continue to cause delays and force inefficient production line workarounds where unfinished work is completed out of station.[6] Production data provided by the Defense Contract Management Agency (DCMA) show continuing critical part shortages, high change traffic, out-of-station work, quality issues, and planning rework. These conditions have also delayed efforts to mature and demonstrate the production process even as work begins on the first production lot. The contractor has not yet proven it can efficiently build the JSF, and test aircraft are being built differently from the process expected for the production aircraft.

The first test aircraft, a non-production-representative conventional landing prototype completed in 2006, required 65,000 more labor hours (about 35 percent more) to build than planned. It encountered most of its inefficiencies in the wing and final assembly phases. The second test aircraft, a STOVL model, left the production line in December 2007, and its first flight is expected in May 2008, 8 months later than originally scheduled. It cost about 25-30 percent more to build than planned. Contractor data show that the wings were only three-fifths complete when moved to final assembly. As a result, over 25,000 more labor hours had to be performed out of station to complete the wing assembly for this aircraft.

Table 2 shows work performance on the first seven test aircraft to enter manufacturing. (This does not include the original prototype completed in

[6] An efficient production line establishes an orderly flow of work as a product moves from workstation to workstation and on to final assembly. Out-of-station work, sometimes referred to as traveled work, refers to completing unfinished work on major components, e.g., the wings, after they have left the wing workstation and moved down the production line to another station.

December 2006.) These data show that nearly all aircraft are persistently behind schedule in completing work on these three critical components at the Fort Worth, Texas, facility. In terms of cost, the data show overall good performance in constructing the forward fuselage, but poor results for the wing and final assembly.

Table 2: Manufacturing Performance Data, End of September 2007

Development aircraft	Forward fuselage		Wing		Final assembly	
	Days behind[a]	Cost efficiency[b]	Days behind	Cost efficiency	Days behind	Cost efficiency
STOVL-1	In mate	119%	In mate	69%	-	77%
STOVL-2	-19	148%	-129	65%	-	69%
STOVL-3	-34	133%	-134	49%	-	-
STOVL-4	-68	115%	-162	41%	-	-
CTOL -1	-73	139%	-279	23%	-	-
CTOL-2	-35	78%	-283	-	-	-
CTOL-3	-35	58%	-140	-	-	-

Source: GAO analysis of Defense Contract Management Agency data

[a]This column represents the number of days the aircraft were behind in manufacturing and assembly of these components.

[b]The cost efficiency column is a measure of how well the component is actually performing financially in relation to earned budgets. Cost efficiency of 100 percent or higher indicates good performance; scores under 100 indicate production inefficiencies.

Because of production inefficiencies and delays, the contractor has had to lengthen the manufacturing schedule three times to provide more time to complete work. Production line problems have resulted in slips of between 11 and 16 months to first flight dates for each variant. At the time of our review, a fourth schedule was being prepared that would add another 1 to 4 months to schedules. Officials are reporting some improvements in parts shortages, assembly, and product quality, but expect the cascading effects from the design delays and manufacturing inefficiencies to linger for another couple of years.

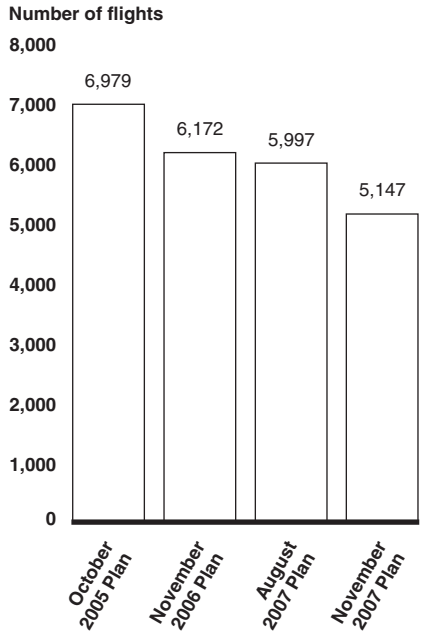
Development Flight Test Efforts Are Beginning with Fewer Assets and Revised Verification Strategy

The flight test program has just begun, with only about 25 flights completed as of January 2008. The program had originally planned to conduct development flight tests using 15 aircraft. The recent decision to reduce test aircraft to 13 (including the prototype), cut back the number of flights, and change how some capabilities are tested will stress resources, compress time to complete testing, and increase the number of

development test efforts that will overlap the planned start of operational testing in October 2012. Test officials are concerned that capacity will be too constrained to meet schedules and to adequately test and demonstrate aircraft in time to support operational testing and the full-rate production decision in October 2013. The full extent of changes and impacts from a revised test verification strategy are still evolving. Program officials reported that if test assets become too constrained, production aircraft may eventually be used to complete development testing.

The number of development flight tests had already been reduced twice before the Mid-Course Risk Reduction plan, as shown in figure 3. Test flights have now been reduced by more than 1,800 flights (26 percent) over the last 2 years.

Figure 3: JSF Development Flight Tests Planned



Source: GAO analysis of DOD data.

Other test issues and events included the following:

- Flight tests started with the initial development test aircraft, which is not considered to be a production-representative aircraft. According to program officials, initial flights of this aircraft yielded very useful information on flight characteristics. However, three incidents—an electrical flight control actuator malfunction in-flight and an engine

blade failure during a ground test—delayed further testing from May to December 2007. Another blade failure occurred in February 2008.

- Initial flights of the Cooperative Airborne Test Bed aircraft in 2007 verified its airworthiness, and it was then modified to integrate some JSF systems hardware and software. In December 2007, it began some limited mission flight tests, but is not yet fully configured. The Mid-Course Risk Reduction plan revised the development test verification strategy to increase reliance on this specially configured aircraft to test capabilities that were going to be demonstrated on JSF aircraft.

- An operational assessment by testers from the Navy, Air Force, and the United Kingdom's Royal Air Force was accomplished from March 2004 to December 2005 to assess development progress and current JSF mission capability. The February 2006 report concluded that the baseline flight test schedule provided little capability to deal with unforeseen problems and still meet the scheduled start of operational test and evaluation in October 2012. Testing officials said the JSF flight test program was following the historical pattern of legacy programs in making overoptimistic plans and using assumptions not supported by historical data. In legacy aircraft, these practices resulted in capacity constraints, program slips, and reduced testing tasks. We note that these concerns about the JSF were expressed at a time when the test program was expected to have the full complement of 15 test aircraft, not the 13 now planned.

Development Challenges Have Been Exacerbated by Inattention to Best Acquisition Practices

A program as complex and technically challenging as the JSF would be expected to have some setbacks, but we believe that the cause of many cost and schedule problems can be traced to an acquisition strategy and decisions at key junctures that did not adequately follow the best practices we have documented in successful commercial and government programs.[7] The JSF started system development before requisite technologies were ready, started manufacturing test aircraft before designs were stable, and moved to production before flight tests have adequately demonstrated that the aircraft design meets performance and operational suitability requirements. We previously reported that the JSF acquisition strategy incorporated excessive overlap in development and

[7] For an overview of the best practices methodologies and how current defense programs fared, see our report of last year on major acquisitions, including the JSF, in GAO, *Defense Acquisitions: Assessments of Selected Weapon Programs*, GAO-07-406SP (Washington, D.C.: Mar. 30, 2007).

production, posing substantial risks for cost overruns, schedule slips, and late delivery of promised capabilities to the warfighter.[8]

Six years after system development start, only two of the JSF's eight critical technologies are mature by best practice standards, three are approaching maturity, and three are immature. Maturing critical technologies during system development led to cost growth. For example, development costs for the electric-hydraulic actuation and power thermal management systems have increased by 195 and 93 percent respectively since 2003.

All three variants fell significantly short of meeting the best practices standard of 90 percent of drawings released at the times of their respective critical design reviews: 46 percent for the STOVL, 43 percent for the CV, and 3 percent for the CTOL. Design delays and changes to designs were cited by the Mid-Course Risk Reduction team as the precipitating cause leading to the depletion of management reserves. The late release of drawings resulted in a cascading of problems in establishing suppliers and manufacturing process, which led to late parts deliveries, delayed the program schedule, and forced inefficient manufacturing processes to compensate for the delay.

Also, the program began initial low-rate production in 2007 before delivering an aircraft that fully represents the expected design. Efforts to mature production are constrained because the designs are not fully proven and tested, and manufacturing processes are not demonstrated. A fully integrated, capable production aircraft is not expected to enter flight testing until fiscal year 2012, increasing risks that problems found may require redesign, production line changes, and retrofit expenses for aircraft already built.

Program Costs Expected to Increase and Schedule Worsen

On the basis of the evidence, we expect JSF program costs to increase and the schedule worsen to the point where the development period will likely need to be extended and Initial Operational Test and Evaluation (IOT&E) and full-rate production delayed. A major program restructure seems inevitable, unless significant elements of the program can be safely eliminated or deferred. The Mid-Course Risk Reduction plan does not directly address design and manufacturing inefficiencies that created the

[8] GAO-05-271.

problem in the first place. If the root causes are not identified and fixed, the rapid depletion of management reserves can be expected to continue, and more funding will be needed to complete development.

There is no reason to believe that these problems can be easily and quickly fixed. While there have been some assembly line improvements, program officials expect the manufacturing problems to persist for about 2 more years. Officials hope this plan will give them a period of time to better and more fully assess all the issues and reevaluate development costs and schedule requirements. They are depending on the revised test verification plans to maintain the pace and efficacy of development testing, but the test community is dubious. What seem more likely are additional costs and time to overcome inadequate capacity and the elimination or deferral of more test activities. Eliminating development test activities and deferring additional tasks to be completed during operational testing increase the likelihood that design and performance problems will not be identified and resolved until late in the program, when it is more costly and disruptive and could delay the delivery of capabilities to the warfighter.

There are also abundant other indicators that acquisition costs will substantially increase from what is now being reported to Congress. Specifically:

- DOD has identified billions of dollars in unfunded requirements that are not in the program office estimate, including additional tooling and procurement price hikes.
- A new manufacturing schedule in the works indicates continued degradation in the schedule and further extends times for first flights.
- Both the aircraft and engine development contracts have persistent, substantial cost variances that cost analysts believe are too large and too late in the program to resolve without adding to budget.
- The prime contractor and program office are readying a new estimate at completion, which is expected to be much larger than what is now budgeted.
- Three defense organizations independent of the JSF program office have all concluded that the program office's cost estimate is significantly understated and the current schedule unlikely to be achieved.

For these and other reasons, we believe that the current JSF cost and schedule reported to Congress are not reliable for decision making, as discussed next.

JSF Program Cost Estimate Is Not Reliable

The $299.8 billion acquisition cost estimate for the JSF program is not reliable because it is not sufficiently comprehensive, accurate, documented, or credible. GAO's *Cost Assessment Guide* outlines best practices used throughout the federal government and industry for producing reliable and valid cost estimates. We assessed the cost-estimating methodologies used by the JSF program office against these best practices and determined that certain key costs were excluded, assumptions used were overly optimistic, documentation was inadequate, and no analysis had been done to state the confidence and certainty the program office had in its cost estimate. As a result of these weaknesses, the JSF program acquisition cost estimate is not reliable for decision making. Appendix II contains a more detailed discussion of the specific shortcomings we and the other DOD organizations have found in the program office cost-estimating methodologies and their potential impacts.

The JSF Cost Estimate Is Not Comprehensive

Estimates are comprehensive when they contain a level of detail that ensures that all pertinent costs are included and no costs are double-counted. It is important to ensure the completeness, consistency, and realism of the information contained in the cost estimate. Our review of the JSF development cost estimate showed that there are several cost categories totaling more than $10 billion that are excluded or underreported in the program office estimate. These items are summarized in table 3 below.

Table 3: Costs Excluded from the Program Office Acquisition Cost Estimate

Cost item	Possible impact
Alternate engine	$6.8 billion
Military construction	$1.5 billion
Tooling	$2.1 billion
Capabilities dropped from development	Unknown
Total	**$10 billion plus**

Source: GAO analysis of DOD data

Specifically:

- The current acquisition cost estimate includes only near-term development funding for the alternate engine program, excluding procurement-related and other development costs of about $6.8 billion.
- The military services have not firmly established basing needs for the entire planned JSF force, but an earlier top-line estimate for military construction was at least $2 billion. The current total cost estimate includes only near-term budgeted costs of $533 million.
- The JSF program recently increased its estimate of tooling costs by $2.1 billion due to the inclusion of additional tooling requirements and estimating methodology changes.
- Cost and performance trade-offs during development deferred some requirements from the current program that may later require additional funding. The program office has not quantified these deferrals, but Naval Air Systems Command (NAVAIR) officials told us that the amount could be in the billions of dollars.

The JSF Cost Estimate is Not Accurate

Estimates are accurate when they are based on an assessment of the costs most likely to be incurred. Therefore, when costs change, best practices require that the estimate be updated to reflect changes in technical or program assumptions and new phases or milestones. DOD's Cost Analysis Improvement Group (CAIG) found that the assumptions the JSF program office used for weight growth, staffing head counts, commonality savings for similar parts, and outsourced labor rate savings were overly optimistic and not supported by historical data.[9] For example, the program office had used a 3 percent factor for weight growth whereas the CAIG used a 6 percent factor more in line with historical data from other programs. With three variants, a joint program with international participation, three different engines (cruise, second engine, and lift) in development, and more than double the amount of operational flight software lines of code than the F-22A and more than four times that of the F/A-18E/F, the JSF

[9] The CAIG serves as the principal advisory body to the milestone decision authority on all matters concerning an acquisition program's life-cycle cost, and is given general responsibilities for establishing DOD policy guidance on a number of matters relating to cost estimating. The independent CAIG cost estimate is designed to assess the program office estimate and ensure realistic cost estimates are considered.

program is substantially more complex than the F-22 or F/A-18E/F, and therefore may not merit assumptions that are even as optimistic as the historical data for those programs.

The program cost estimate is also considered inaccurate because it relies on data and reports found to be deficient. JSF program office used Lockheed Martin earned value management (EVM) data in estimating development costs.[10] However, DCMA determined that the data as being of very poor quality and issued a report in November 2007 stating that it is deficient to the point where the government is not obtaining useful program performance data to manage risks. Among other problem areas, DCMA found that the contractor was using management reserve funds to alter its own and subcontractor performance levels and cost overruns. DCMA officials who conducted the review told us that the poor quality of the data invalidated key performance metrics regarding cost and schedule, as well as the contractor's estimate of the cost to complete the contract. At the time of our review, corrective actions and plans were in process.

The JSF Cost Estimate Is Not Well Documented

Cost estimates are well documented when they can be easily repeated or updated and can be traced to original sources through auditing. Rigorous documentation increases the credibility of an estimate and helps support an organization's decision-making process. The documentation should explicitly identify the primary methods, calculations, results, rationales, assumptions, and sources of the data used to generate each cost element. All the steps involved in developing the estimate should be documented so that a cost analyst unfamiliar with the program can recreate the estimate with the same result.

We found that the JSF cost model is highly complex and the level of documentation is not sufficient for someone unfamiliar with the program to easily recreate it. Specifically, we found that the program office does not have formal documentation for the development, production, and operation and support cost models and could not provide detailed documentation such as quantitative analysis to support its assumptions. For the development cost estimate, the JSF program officials said they did not have a cost model that was continually updated with actual costs.

[10] Earned value management is a method of tracking and measuring the value of work accomplished in a given period and comparing it with the planned value of work scheduled and the actual cost of work accomplished. Its use is required by federal regulations.

Instead the program office relies heavily on earned value management data and contractor analysis to update its development cost estimate.

The JSF Cost Estimate Is Not Credible

Estimates are credible when they have been cross-checked with an independent cost estimate and when a level of uncertainty associated with the estimate has been identified. An independent cost estimate provides the estimator with an unbiased test of the reasonableness of the estimate and reduces the cost risk associated with the project by demonstrating that alternative methods generate similar results.

Several independent organizations have reviewed the JSF program and are predicting much higher costs than the program office. Table 4 below provides a summary of these assessments.

Table 4: Outside Organizations' Assessments of JSF Cost and Schedule

Assessing organization	Impact on cost	Impact on schedule
CAIG	$5.1 billion more for development, over $33 billion more for procurement	12 months slip
NAVAIR	$8 billion to $13 billion additional development costs or trade-offs adding to procurement costs	19-27 months slip
DCMA	$4.9 billion additional cost to complete Lockheed Martin development contract	Up to 12 months slip

Source: CAIG, NAVAIR, DCMA.

CAIG estimates were prepared using different and more realistic assumptions and schedule projections than the program office estimate. NAVAIR, which provides resources to the JSF program office cost-estimating function, derived much higher cost estimates and a longer development period based on historical cost performance and removing what it considered to be artificial and unachievable schedule constraints. Officials were also concerned about the amount and future impact of requirements potentially traded or pushed off into the procurement phase, which could be even more costly. DCMA projected higher development costs for the aircraft contract based on adjusted cost and schedule performance to date and assuming additional slips. Officials continue to examine the contractor's deficient earned value management system and its misreporting of cost and schedule data.

DOD Intends to Wait to Make a New and Independent Cost Estimate

The JSF program has not conducted a fully documented independent cost estimate since system development start in 2001. Despite reliability concerns and all the significant events and changes in cost, schedule, and quantity since then—those reported by the program office as well as those identified by other defense organizations and us—DOD does not intend to accomplish another one until required to support the full-rate production decision in 2013. If so, this will mean that the program—DOD's largest acquisition and vitally important to our allies—will have a 12-year gap between official validated cost estimates. The program may complete development and be 6 years into production before an accurate, up-to-date, and reliable official cost estimate is done.

Despite widely held views that costs will likely be higher and the schedule longer than reported, the JSF program continues to be funded to the level of the program office estimate. DOD acquisition policy requires fully documented total program life-cycle cost estimates, with validation by the CAIG, at certain major decision points and when mandated by the milestone decision authority. DOD officials decided not to do such an estimate at the start of low-rate initial production in 2007, which typically coincides with a major milestone.

Future Challenges as Program Moves Forward

The JSF is entering its most challenging phase as it finalizes three designs, matures manufacturing processes, conducts flight tests, and ramps up production. The first and foremost challenge is maintaining affordability in three dimensions—reasonable procurement prices, stable annual funding, and economical life-cycle operating and support costs. If affordability is not maintained during the acquisition program, quantities bought by the United States and allies may either decrease or else consume more of the available defense budgets. Over the life cycle of a system, higher costs for maintaining readiness and maintainability drive up annual operating expenses and may limit funds for new investments. Other program challenges could affect future quantities and the mix of aircraft procured by the United States and our allies.

Affordability Concerns Have Major Repercussions

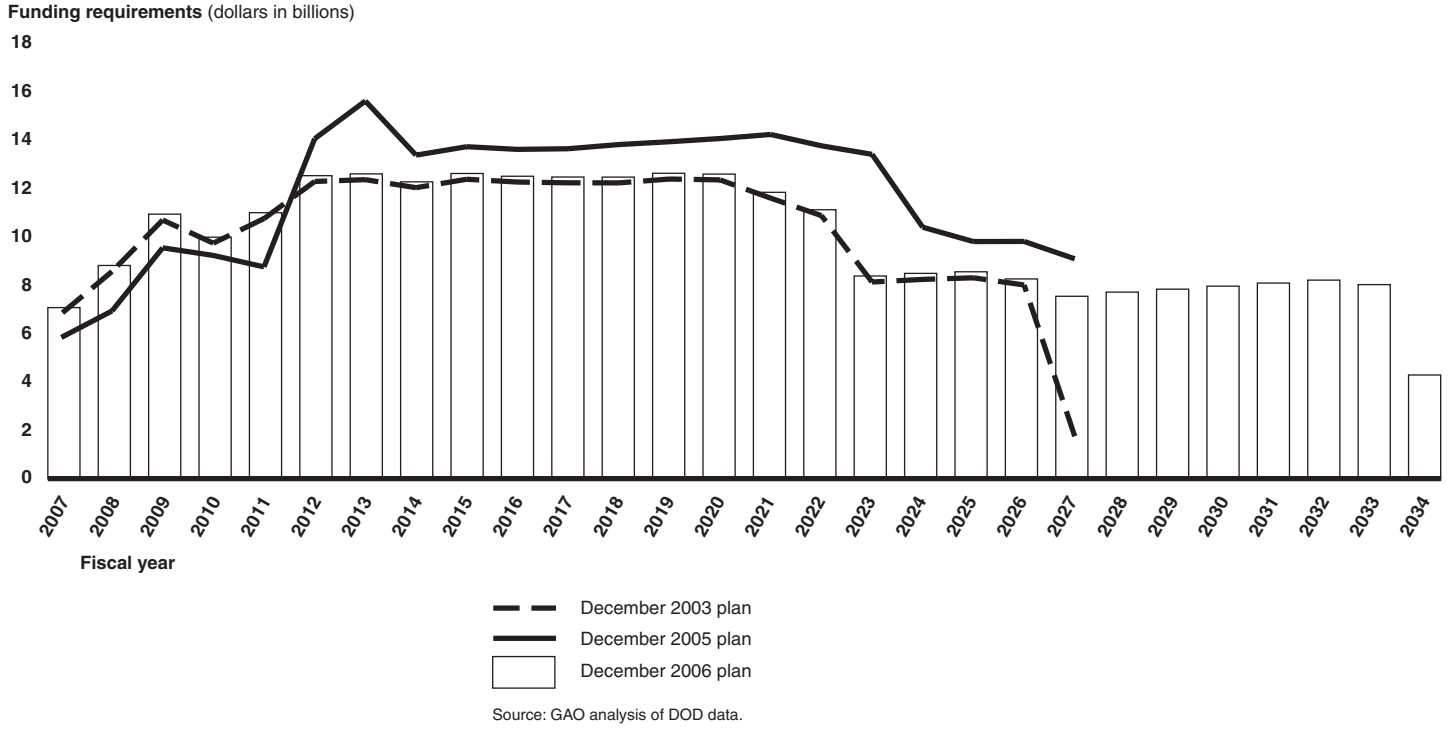
From its outset, the JSF goal has been to develop and field an affordable, highly common family of strike aircraft. Rising unit procurement prices, and somewhat lower commonality than expected, raise concerns that the United States and its allies may not be able to buy as many aircraft as currently planned. Average unit procurement costs are up 27 percent since the 2004 Replan and 51 percent since the start of system development (see

table 1). Rising prices erode buying power, likely resulting in reduced quantities and delays in delivering promised capabilities to the warfighter.

The program also places an unprecedented demand for funding on the defense budget—an annual average of about $11 billion for the next two decades--with attendant funding risk should political, economic or military conditions change. The JSF will have to annually compete with other defense and nondefense priorities for the shrinking discretionary federal dollar. To complete the acquisition program as currently planned, JSF will require about $269 billion from 2008 through 2034. Annual funding requirements for procurement increase rapidly as production ramps up to the full-rate production decision expected in October 2013. During the peak years of production, JSF procurement funding requirements are expected to average about $12.5 billion per year for the 12-year period spanning fiscal years 2012-2023.

Figure 4 illustrates the annual funding requirements as of December 2006 and contrasts these with plans from prior years. The December 2003 line shows the funding profile resulting from the 2004 Replan and the 2005 line shows the jump in funding needed to accommodate program cost increases in the period following the Replan. The 2006 data reflect the impact on annual funding requirements from extending procurement 7 years. The extension reduced annual budget amounts, but requires continued funding through 2034 to procure deferred quantities. DOD calculated that the extension added $11.2 billion to total procurement cost.

Figure 4: JSF Acquisition Program's Annual Funding Requirements



Source: GAO analysis of DOD data.

A third aspect of affordability is the life-cycle cost of ownership. DOD is recapitalizing its tactical air forces by replacing aging legacy systems with new, more capable systems, like the JSF, that incorporates reliability and maintainability features designed to reduce future operating costs. Recently, DOD sharply increased its projection of JSF operating and support costs compared to previous estimates. The December 2006 SAR projected life-cycle operating and support costs for all three variants at $650.3 billion, almost double the $346.7 billion amount shown in the December 2005 SAR and similar earlier estimates. The operating cost per flying hour for the JSF CTOL is now estimated to be greater than current flying hour cost for the F-16, one of the legacy aircraft to be replaced.

Officials explained that the amounts reported in 2005 and before were early estimates based on very little data, whereas the new estimate is of higher fidelity, informed by more information as JSF development progresses and more knowledge is obtained. Factors responsible for the increased cost estimate included a revised fielding and basing plan, changes in repair plans, revised costs for depot maintenance, increased fuel costs, increased fuel consumption, revised estimates for manpower

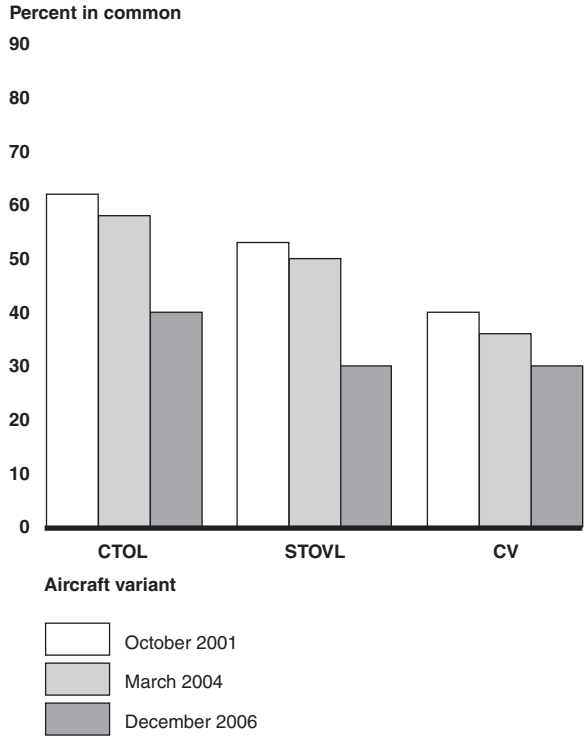
and mission personnel, and a new estimate of the cost of the JSF's autonomic logistics system.

Overall, the cost of ownership represents a very large and continuing requirement for the life of fielded aircraft. According to the new estimate, we calculate that DOD will incur about $24 billion per year to operate and support JSF units, assuming the quantities now planned and an 8,000-hour service life for each JSF aircraft fielded over time.

Commonality Is Less than Expected

From the inception of the program, DOD has anticipated major cost savings from developing and fielding JSF variants that share many common components and subsystems. While a degree of commonality has been achieved, expectations are now lower than they were at program start. Substantial commonality has been maintained for the mission systems among all three variants and for the propulsion system of the conventional and carrier variants. However, commonality among airframes and vehicle systems has declined overall since the start of system development. Figure 5 shows the decline in airframe commonality, the most costly of the four major categories. For example, in October 2001 DOD anticipated that the CTOL airframe would be more than 60 percent common with the other variants. Commonality had declined to about 40 percent by December 2006. Lesser commonality will likely increase acquisition and future support costs.

Figure 5: Changes in Airframe Commonality



Source: GAO analysis, DOD data.

Navy and Marine Corps Requirements and Mix Are Unsettled

The current JSF program shows a total quantity of 680 aircraft to be procured by the Department of the Navy, but the allocation between the CV and STOVL variants has not been officially established. We observe that the Navy and Marine Corps have somewhat divergent views on the quantities, intended employment, and basing of JSF aircraft. The Navy wants the Marine Corps to buy some CV variants and continue to man some of its carrier-based squadrons. The Marine Corps, however, wants to have a future strike force composed solely of the STOVL variant and has established a requirement for 420 aircraft. During conflicts, the Marines plan to forward deploy JSFs to accompany and support the expeditionary ground forces.

Navy officials told us that they have some time to make decisions because they will be buying a mix of both CVs and STOVLs in the early years of production and that funding requirements are not significantly affected since unit prices for both variants are about the same. However, we

believe the continuing disagreements on basing, employment, and force mix will have increasingly stronger impacts on JSF plans, costs, and international partner relations. Decreased quantities of STOVLs bought by the Department of the Navy would likely result in higher unit prices paid by the Marine Corps and two allies buying STOVLs. Fundamental decisions on the mix of naval aircraft also affect future operating and support costs, military construction, and carrier requirements.

Officials also have some reservations whether they can afford the quantities now planned at peak production rates. Navy and Marine Corps officials told us last year that buying the JSF at the current planned rate—requiring a ramp-up to 50 CV and STOVL aircraft by fiscal year 2015—will be difficult to achieve and to afford, particularly if costs increase and schedules slip. Officials told us that a maximum of 35 per year was probably affordable, given budget plans at that time.[11]

Containing Future Weight Growth

Weight growth was the most significant challenge faced by the JSF program early in development. Redesign efforts to address weight growth was the single largest factor causing the $10 billion cost increase and 18-month extension in the development schedule since the start of system development.

While the weight increase has been addressed for now, projections are that the aircraft weight will continue to increase during the balance of the development period, consistent with weight increases seen on legacy aircraft programs. According to an OSD official with knowledge of legacy aircraft development efforts, half of all weight growth during the development effort can be typically expected after first flight but prior to initial operational capability, and that additional small but persistent weight increases can be expected during the aircraft's service life. First flight of a production-representative JSF has not yet occurred, and weight is running very close to the limits as evaluated by engineering analyses and trend extrapolation. As designs continue to mature and flight testing intensifies, maintaining weight within limits to meet warfighter capability requirements will be a continuing challenge and pose a major risk to meeting cost, schedule, and performance goals.

[11] GAO, *Tactical Aircraft: DOD Needs a Joint and Integrated Investment Strategy*, GAO-07-415 (Washington, D.C.: Apr. 2, 2007).

Conclusions

The clear implication from performance to date and the Mid-Course Risk Reduction plan is that additional costs and time will be needed to complete JSF development. The plan to recapitalize management reserve at the expense of test assets is risky with potential major impacts down the road on costs, performance requirements, and fielding schedules. The remaining development effort will be less robust than originally planned and depends on a revised test verification strategy that is still evolving. As a result, the development effort has an increased risk of not fully measuring JSF capabilities and deficiencies prior to operational testing and could result, in the words of one DOD official, in the future operational test period being one of discovery rather than validation of the aircraft's capabilities and deficiencies. Finding and fixing deficiencies during operational testing and after production has ramped up is costly, disruptive, and delays getting new capabilities to the warfighter.

Because the program cost estimate is not reliable when judged against best standards, the decision making and oversight by Congress, top military leaders, and our allies are diminished. The picture they do have is one where costs continue to rise and schedules slip. The situation will be considerably worsened if the cost estimates of defense offices outside the program are more accurate than the conservative, official in-house estimates. Waiting 12 years between fully documented and validated total program cost estimates is contrary to policy and good management, given all the changes in cost, quantity, schedules, and other events that have occurred since the 2001 estimate. The size of the JSF acquisition, its impact on our and allied tactical air forces, and the unreliability of the current estimate argue for an immediate new and independent cost estimate and uncertainty analysis. This is critical information needed by DOD management to make sound trade-off decisions against competing demands and by Congress to perform oversight and hold DOD accountable.

Program problems and setbacks must be put into perspective: The JSF is DOD's largest and most complex aircraft acquisition and an integral component of the future force. Problems happen in such an environment. Progress has been made and some significant challenges overcome, but more await as program moves into flight testing and low-rate production. Maintaining affordability so the United States military and our allies can buy, field, and support the numbers needed by the warfighter remains the overarching challenge.

Recommendations for Executive Action

Because of the elevated risks and the valid objections raised by the test community and other DOD offices, we recommend that the Secretary of Defense direct elements of the department to revisit and, if appropriate, revise the Mid-Course Risk Reduction plan recently approved. This should be supported by an intensive analysis that includes causes of management reserve depletion, an evaluation of progress against the baseline manufacturing schedule, and the progress made in correcting deficiencies in the contractor's earned value management system. It should also include an in-depth examination of alternatives to the current plan and address the specific concerns raised by officials regarding testing capacity, the integration of ground and flight tests, and backup plans should capacity become overloaded.

So that DOD may have an accurate picture of JSF cost and schedule requirements, and that Congress may have an accurate understanding of future funding requirements, we recommend that the Secretary of Defense direct that

1. The JSF program office update its cost estimate using best practices, so that the estimate is comprehensive, accurate, well documented, and credible. Specifically, the JSF program office should

- include costs that were inappropriately omitted from the estimate;
- identify performance requirements that have been traded off in development;
- fully document assumptions, data sources and methodologies in the cost model; and
- perform a risk and uncertainty analysis to focus on key cost drivers and reduce the risk of cost overruns.

2. The program conduct a full Schedule Risk Analysis to ensure that its schedules are fully understood, manageable, and executable;

3. DOD conduct a full, independent cost estimate should be conducted according to the highest standards of any DOD cost estimating organization, based on a comprehensive review of program data; that this cost estimate be reviewed by an independent third party such as the CAIG; and that the results of these estimates be briefed to all interested parties in DOD and Congress.

Agency Comments and Our Response

DOD provided us with written comments on a draft of this report. The comments appear in appendix III. DOD also provided several technical comments, which we incorporated in this report.

DOD substantially agreed with our recommendation to revisit the Mid-Course Risk Reduction plan. DOD stated that the plan is a cost-effective approach with a manageable level of risk that will be monitored and revised if necessary. We believe the plan's reduction of test resources will hamper development testing and that the Department will eventually have to make programmatic adjustments, adding cost and time.

DOD also substantially agreed with our three recommendations on cost estimating. DOD indicated that it will implement all elements except the risk and uncertainty analysis, which is unwarranted in its view. We believe that risk and uncertainty analysis is an important tool that establishes a confidence interval for a range of possible costs—as opposed to a single-point estimate—and facilitates good management decisions and oversight. Such analysis is a best practice in our *Cost Assessment Guide* and we note that OSD's Cost Analysis Improvement Group supports and uses this cost-estimating tool.

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. Staff members making key contributions to this report are listed in appendix IV.

Michael J. Sullivan
Director
Acquisition and Sourcing Management

List of Congressional Committees

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

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

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

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

Appendix I: Scope and Methodology

To determine the Joint Strike Fighter (JSF) program's progress in meeting cost, schedule, and performance goals, we received briefings by program and contractor officials and reviewed financial management reports, budget documents, annual Selected Acquisition Reports, monthly status reports, performance indicators, and other data. We compared reported progress with prior years' data, identified changes in cost and schedule, and obtained officials' reasons for these changes. We interviewed Department of Defense (DOD), JSF program, and contractor officials to obtain their views on progress, ongoing concerns and actions taken to address them, and future plans to complete JSF development and ramp up procurement.

To assess plans and risks in development, manufacturing, and test activities, we examined program documents and interviewed DOD and contractor officials about changes to the test plan and actions taken to modify these plans to address funding and schedule challenges. This included reviewing and interviewing program and Office of the Secretary of Defense (OSD) officials about changes to development testing that evolved in response to a projected shortfall in management reserves and a goal to stay on schedule toward a full-rate production decision in October 2013. We reviewed information compiled by program officials to document options they considered viable, changes to the test plan and test resources that would occur under a proposed risk reduction option, and challenges/risks to taking this course of action and possible fallback plans. We also reviewed stakeholder views of options and the benefits and challenges of going forward with the changes made to the development test plan. We collected manufacturing cost and work performance data to assess progress against plans, determined reasons for manufacturing delays, discussed program and contractor plans to improve, and expected impacts on development and operational tests.

In assessing program cost estimates, we also evaluated the JSF joint program office estimating methodologies, assumptions, and results to determine whether the official cost estimates were comprehensive, accurate, well documented, and credible. We used our draft guide on estimating program schedules and costs, which is based on extensive research of best practices. Our *Cost Assessment Guide* considers an estimate to be accurate if it is not overly conservative, is based on an assessment of the most likely costs, and is adjusted properly for inflation; comprehensive if its level of detail ensures that all pertinent costs are included and no costs are double-counted; well documented if the estimate can be easily repeated or updated and can be traced to original sources through auditing; and credible if the estimate has been cross-

checked with an independent cost estimate and a level of uncertainty associated with the estimate has been identified. We also interviewed the JSF program office's cost estimating team to obtain a detailed understanding of the cost model and met with the Department of Defense Cost Analysis Improvement Group (CAIG)[1] to understand their methodology, data and approach in developing their Joint Strike Fighter independent cost estimate. We analyzed earned value management (EVM)[2] reports and met with the Naval Air Systems Command and the Defense Contract Management Agency (DCMA) to discuss the EVM data and to obtain their independent cost estimates for JSF development efforts. To assess the validity and reliability of prime contractors' earned value management systems and reports, we analyzed the EVM reports and reviewed audit reports prepared by the DCMA.

To identify future challenges, we continued discussions with DOD and contractor officials on forward-looking plans and areas of emphasis. We analyzed budget requirements from successive plans and tracked contributing factors to changes in budget. We collected information on commonality assessments among the three variants and trends. With Navy and Marine Corps officials, we discussed future plans on the employment and quantity mix of aircraft and identified differences in plans and perspectives. We discussed past and present weight growth issues with engineers and plans for controlling future growth.

In performing our work, we obtained information and interviewed officials from the JSF Joint Program Office, Arlington, Virginia; Aeronautical Systems Center, Wright-Patterson Air Force Base, Ohio; Naval Air Systems Command, Patuxent River, Maryland; Defense Contract Management Agency, Fort Worth, Texas; and Lockheed Martin Aeronautics, Fort Worth,

[1] The CAIG serves as the principal advisory body to the milestone decision authority on all matters concerning an acquisition program's life-cycle cost, and is given general responsibilities for establishing DOD policy guidance on a number of matters relating to cost estimating. The independent CAIG cost estimate is designed to assess the program office estimate and ensure realistic cost estimates are considered.

[2] Earned value management is a method of tracking the value of work accomplished in a given period and comparing it with the planned value of work scheduled and the actual cost of work accomplished. Its use is required by federal regulations. EVM places special emphasis on efficiently and effectively executing work through the development and operation of management control system that includes people, systematic processes, and innovative tools and techniques. The intent of EVM is to help program managers, and the teams who support them, be successful by allowing them to operate productively in the high-risk environments surrounding them.

Texas. We also met and obtained data from the following OSD offices in Washington, D.C.: Director, Operational Test and Evaluation; Program Analysis and Evaluation; Cost Analysis Improvement Group; Portfolio Systems Acquisition (Air Warfare); and Systems and Software Engineering. We conducted this performance audit from June 2007 to February 2008 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: GAO Assessment of JSF Program Cost Estimate

The Current JSF Program Office Acquisition Cost Estimate Is Not Reliable

The $299.8 billion acquisition cost estimate for JSF is not reliable because it is not sufficiently comprehensive, accurate, documented, or credible. Cost-estimating organizations throughout the federal government and industry use certain key practices to produce sound cost estimates that are comprehensive and accurate and that can be easily traced, replicated, and updated. GAO's *Cost Assessment Guide* outlines practices that, if followed correctly, should result in high-quality, reliable, and valid cost estimates that management can use for making informed decisions. We assessed the methodology used by the JSF program office to determine its development cost estimate against four best practices characteristics, which are that an estimate should be comprehensive, accurate, well documented, and credible.[1] We found that the JSF program office has not followed best practices for developing a reliable and valid life cycle cost estimate because it did not include certain key costs, assumptions used to develop the estimate are overly optimistic, the estimate is not well documented, and no analysis has been done to state the confidence and certainty it has in its estimate. As a result of these weaknesses, the JSF program acquisition cost estimate is not reliable for decision making.

The JSF Cost Estimate Is Not Comprehensive

Estimates are comprehensive when they contain a level of detail that ensures that all pertinent costs are included and no costs are double-counted. It is important to ensure the completeness, consistency, and realism of the information contained in the cost estimate. Our review of the JSF development cost estimate showed that there are several cost categories totaling more than $10 billion that are excluded or underreported in the program office estimate. These items are summarized in table 5.

Table 5: Costs Excluded from the Program Office Acquisition Cost Estimate

Cost item	Possible impact
Alternate engine	$6.8 billion
Military construction	$1.5 billion plus
Tooling	$2 billion-$3 billion plus
Capabilities dropped from development and deferred	Unknown
Total	**$10 billion plus**

Source: GAO analysis of DOD data

[1] These four best practice criteria for a reliable, high-quality cost estimate can be mapped to 12 steps of a high-quality cost estimating process that have been identified by GAO in the *Cost Assessment Guide*. Chapter 1 of the guide describes the 12 steps and how they map to the four best practice characteristics.

- *Alternate engine program*. Congress has been interested in DOD developing a second source for the JSF engine to induce competition and to reduce operational risks in the future should the sole engine develop problems requiring the grounding of all JSFs. DOD has not wanted to pursue this second engine source and twice removed funding from the JSF program line. In 2005, DOD deleted a total of about $7.2 billion from the JSF's development and procurement accounts for the alternate engine. In 2006, it reinserted $340 million for the program, reflecting only development funding in the future years defense program. This omits about $6.8 billion left out of the JSF cost estimate for this program.

- *Military construction*. In prior years, the JSF cost estimate included $2 billion for military construction costs. Since the services had not yet fully established basing plans, this amount was a top-level parametric estimate not based on discrete estimates for specific sites. The current December 2006 cost estimate reported military construction costs of $533 million, reflecting only the amount budgeted in the fiscal year 2008 future years defense program. This means that about $1.5 billion in military construction—and possibly more—will eventually be required for specific basing needs of the JSF fleets. DOD will update military construction estimates as the services identify specific site requirements.

- *Tooling*. The JSF program recently increased its estimate of tooling costs due to the inclusion of additional tooling requirements and estimating methodology changes. This change is ongoing, and has not yet been included in official program estimates. According to a recent press report, a Lockheed Martin official stated that the full requirement to support procurement by our allies was not adequately factored into prior tooling estimates. The program estimates the additional cost through 2015 at about $2.1 billion.

- *Deferred capabilities*. Cost and performance trade-offs during development have resulted in some requirements being deleted from the program cost estimate and deferred until later years. This includes a number of planned capabilities dropped from the final block of development software. The program office has not quantified the cost of these deferred capabilities, and the costs are not reflected anywhere in the program office's life-cycle cost estimate. Naval Air Systems Command (NAVAIR) officials told us that the total deferred amount could be in the billions of dollars. We note that prior acquisitions such as the Global Hawk and F-22A programs also deferred requirements that would later need additional funding. For example, we reported in

2005 that the Global Hawk program costs did not include $400.6 million in known additional procurement costs for sensors, ground station enhancements, and other items required to achieve the system's initial full-up capability.[2] These costs had been in the program baseline but were later deferred and reclassified because of cost pressures and schedule changes. Similarly, the Air Force's $5.9 billion modernization and reliability improvement program includes capabilities deferred from the acquisition program and reliability enhancements needed to correct deficiencies and achieve the level of reliability that was supposed to be accomplished during acquisition.

The JSF Cost Estimate Is Not Accurate

Estimates are accurate when they are based on an assessment of the costs most likely to be incurred. Therefore, when costs change, best practices require that the estimate be updated to reflect changes in technical or program assumptions and new phases or milestones. DOD's Cost Analysis Improvement Group found that the assumptions the JSF program office used for weight growth, staffing head counts, commonality savings for cousin (similar) parts, and outsourced labor rate savings could be too optimistic, given the program's complexity. With three variants and three engines (cruise, alternate, and lift) in development, multiple customers, and more than double the amount of operational flight software than the F-22A and four times that of the F/A-18E/F, the JSF acquisition program is substantially more complex than those contemporary systems, and therefore may not merit assumptions that are even as optimistic as the historical data for those programs. The following table shows some major differences in assumptions used by the program office and the CAIG in estimating JSF costs.

[2] GAO, *Unmanned Aircraft Systems: Global Hawk Cost Increase Understated in Nunn-McCurdy Report*, GAO-06-222R (Washington, D.C.: Dec. 15, 2005).

Table 6: Major Assumptions in JSF Cost Estimates

Assumption	JSF Program office	CAIG
Engineering head count	5,000 engineers	3,000 engineers
Weight growth	3% average growth based on Lockheed Martin database	6% based on historical data
Cousin parts (similar, but not identical, parts among the variants)	82% credit for commonality among cousin parts	25% credit for commonality among cousin parts
Labor cost savings for outsourcing	50% cost savings	None – based labor costs on forward pricing rate agreements
Additional 2,000 pounds for carrier variant	No cost increase	Estimated a cost increase
Fee, and "fee on fee" for Northrop Grumman and BAE Systems production items	13% fee on all development and production contracts No "fee on fee" impact	15% fee on all development and production contracts Estimated a "fee on fee" impact
Test failure redesign effort	No additional costs	Additional costs for this effort

Source: JSF program office, CAIG.

JSF program officials told us that they use Lockheed Martin earned value management data in creating their estimate of JSF development costs. However, DCMA, which reviews contracts and industrial performance for DOD, identified this data as being of very poor quality, calling into question the accuracy of any estimate based on these data. In November 2007, DCMA issued a report saying that Lockheed Martin's tracking of cost and schedule information at its aerospace unit in Fort Worth, Texas—where the JSF program is managed—is deficient to the point where the government is not obtaining useful program performance data to manage risks.

DCMA said that Lockheed's earned value data at the Fort Worth facility are not sufficient to manage complex, multibillion-dollar weapon systems acquisition programs. Among other problem areas, DCMA found that Lockheed had not clearly defined roles and responsibilities, and was using management reserve funds to alter its own and subcontractor performance levels and cost overruns. These issues hurt DOD's ability to use the Lockheed data to determine product delivery dates and develop accurate estimates of program costs. DCMA officials who conducted the review at Lockheed Martin told us that the poor quality of the data invalidated key performance metrics regarding cost and schedule, as well as the contractor's estimate of the cost to complete the contract. NAVAIR

had also raised concerns about Lockheed Martin's earned value system as early as June 2005, and these officials told us they were in agreement with the findings in the November 2007 DCMA report. NAVAIR officials also said that most deficiencies identified by the DCMA report have the effect of underreporting costs, and that the official program cost estimates will increase if the deficiencies are corrected.

Also in 2007, the prime contractor alerted DOD to a billing error involving duplicate charges for the portion of the earned award fee paid to subcontractors. This resulted in $266 million in overcharges. Government officials became concerned that such a large discrepancy could occur without the government's knowledge and questioned the adequacy of the contractor's billing system and accounting procedures. DCMA and the Defense Contract Audit Agency were tasked to conduct an investigation. Their investigation found that the overbilling resulted from an accounting system error in the internal handling of award fees on the JSF contract. According to the investigation report, the error that created the overbilling has been corrected, and the government has recouped the overbilled principal and interest.

The JSF Cost Estimate Is Not Well Documented

Cost estimates are well documented when they can be easily repeated or updated and can be traced to original sources through auditing. Rigorous documentation increases the credibility of an estimate and helps support an organization's decision-making process. The documentation should explicitly identify the primary methods, calculations, results, rationales or assumptions, and sources of the data used to generate each cost element. All the steps involved in developing the estimate should be documented so that a cost analyst unfamiliar with the program can recreate the estimate with the same result.

We found that the JSF cost model is highly complex and the level of documentation is not sufficient for someone unfamiliar with the program to easily recreate it. Specifically, we found that the program office does not have formal documentation for the development, production, and operating support cost models. Instead, it relies on briefing slides that describe the methodology and the data sources used, but did not provide detailed documentation such as quantitative analysis to support the assumptions that were involved in producing the life-cycle cost estimate. For the development cost estimate, the JSF program office admitted it did not have a cost model that continually updates with actual costs. Instead the program office relies heavily on earned value management data and

analysis from Lockheed Martin to update its development cost estimate, but provided us no documentation to back up this claim.

The JSF Cost Estimate Is Not Credible

Estimates are credible when they have been cross-checked with an independent cost estimate and when a level of uncertainty associated with the estimate has been identified. An independent cost estimate provides the estimator with an unbiased test of the reasonableness of the estimate and reduces the cost risk associated with the project by demonstrating that alternative methods generate similar results.

Several independent organizations have reviewed the JSF program and are predicting much higher costs than the program office. Table 7 below provides a summary of these assessments.

Table 7: Outside Organizations' Assessments of JSF Cost and Schedule

Assessing organization	Impact on cost	Impact on schedule
CAIG	$5.1 billion more for development, over $33 billion more for procurement	12 months slip
NAVAIR	$8 billion to $13 billion additional development costs or trade-offs adding to cost in procurement	19-27 months slip
DCMA	$4.9 billion additional cost to complete Lockheed Martin contract, including the cost of a 12-month schedule slip	Up to 12 months slip

Source: CAIG, NAVAIR, DCMA.

In 2005, the CAIG performed an independent estimate of JSF program development costs, which include the cost of the Lockheed Martin contract and fees as well as the government's in-house costs. The CAIG expected that the development phase would cost $5.1 billion more than expected by the program office, measured against the program office's most recent data available at that time, from the 2004 Selected Acquisition Report (SAR). The CAIG official in charge of the estimate told us that while it has not formally presented an updated estimate to the program office, the order of magnitude of difference between the CAIG and program office estimates remains roughly the same as at the time of the 2005 independent estimate.

Table 8: JSF Development Program Cost Estimate Comparison
(Then-year dollars in billions)

	JSF	CAIG	Delta between CAIG And JSF
System development start in 2001	$30.2	$31.4	$1.2
December 2004 SAR	$41.5	$46.6	$5.1
Cost growth from 2001 start to 2004 SAR	$11.3	$15.2	$3.9

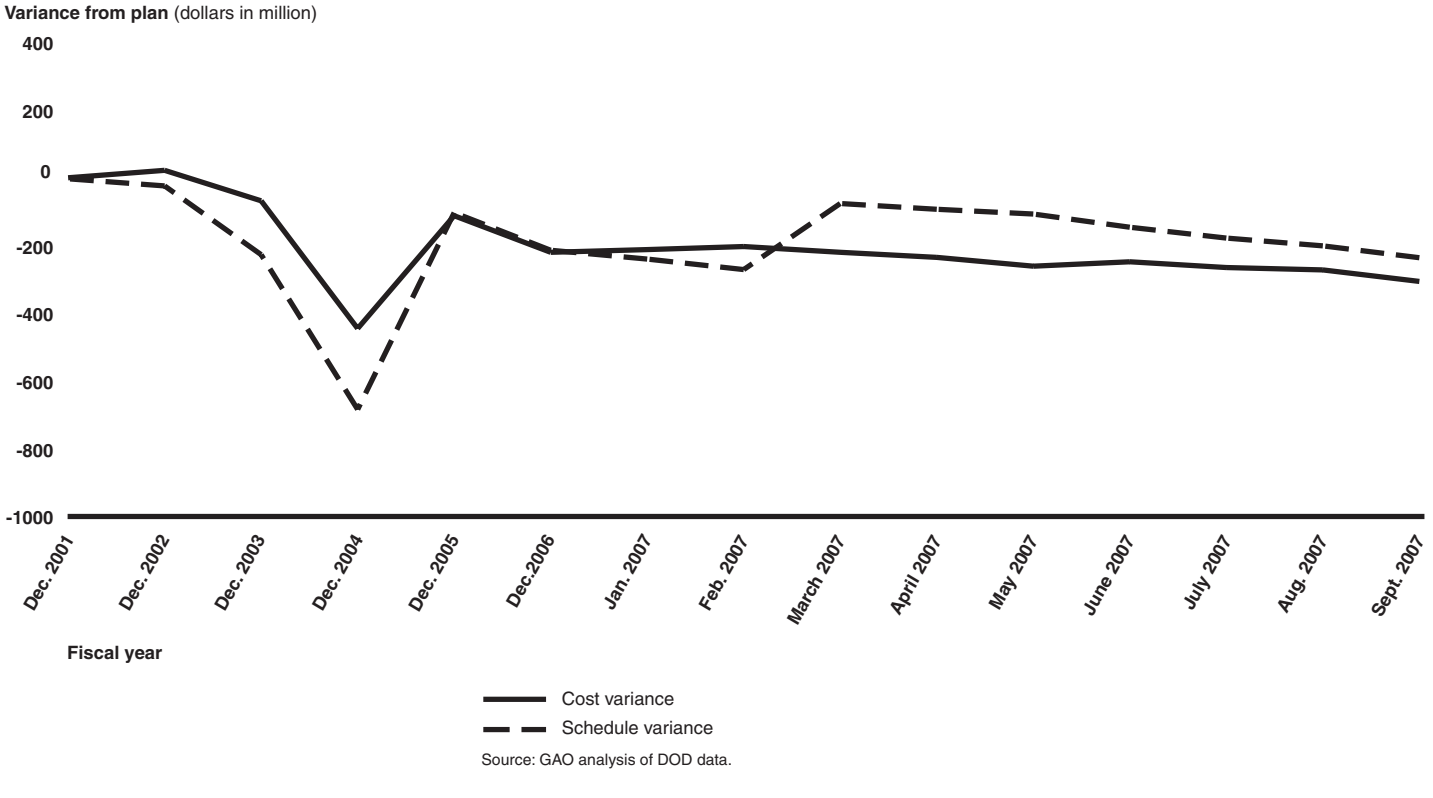
Source: CAIG.

The variance between the CAIG and program office estimates grew significantly as the program encountered problems. The CAIG explained that some of the $15.2 billion growth in its development cost estimate from Milestone B in 2001 to the December 2004 SAR was due to initial assumptions that 5,000 engineers would be available to work on the three JSF variants. This assumption turned out to be too optimistic since only about 3,000 engineers have been working on the program. Because of fewer people available to support the JSF design and development, the CAIG shifted the program schedule to the right, increasing the costs. The program office, on the other hand, assumed it could get the same effort done with fewer people. In addition, the CAIG used historical data from the F-22A program, including the costs to design the aircraft, test it, and redesign any fixes, and adjusted these data to account for differences in the JSF program, including the three variants. The program office relies mostly on contractor data.

When it was awarded the development contract in 2001, Lockheed Martin agreed to develop the JSF aircraft for $16.5 billion, excluding fee. In April 2005, the development program was rebaselined, adding more than $6 billion to reflect funds added to the program due to weight growth issues in 2003. This raised the JSF baseline development contract cost estimate to $23.2 billion, excluding fee.

Despite the additional funding to cover preexisting cost and schedule overruns, Lockheed Martin's JSF development cost and schedule performance has continued to decline over time. As shown in figure 6, cost and schedule variances continued on a downward trend despite the April 2005 rebaseline. As of September 2007, Lockheed Martin was reporting cumulative cost overruns of $305.7 million and was behind schedule to an extent valued at $251.3 million.

Figure 6: Cost and Schedule Variances on the Aircraft Development Contract



Source: GAO analysis of DOD data.

Key drivers of cost overruns to date have included unfunded requirements for design changes, loss of commonality savings, critical part shortages, high change traffic, inefficient productivity due to performing work out of sequence, constant rework, suppliers' performance, late release of engineering requirements, a greater than planned effort for designs of the short takeoff and landing and the conventional takeoff and landing variants, and additional radar testing. Some of this cost variance is due to optimistic assumptions at the beginning of the program. For example, cost estimates assumed that only one design iteration would be needed, whereas in reality it takes numerous design iterations before the final designs are determined.

Despite its poor performance since the rebaseline, Lockheed Martin was predicting only a $113 million cost overrun at contract completion. This is unrealistic given the persistence and size of the $305.7 million overrun reported in September 2007, at which point the contract was 67 percent complete. In order to achieve a $113 million overrun at completion,

Lockheed Martin would have to not only incur no further cost variances from now until completion of the contract, but it would also have to significantly improve its performance. This is unlikely given that studies of more than 700 defense programs have shown limited opportunity for getting a program back on track once it is more than 15 percent to 20 percent complete. The true cost to complete the contract may be significantly greater, as DCMA has expressed its concern to DOD over Lockheed Martin's failure to regularly update its estimate of the costs to complete the JSF contract, stating that Lockheed's infrequent updates are insufficient to provide the government with information bearing on potential cost growth and funding needs.

Like the CAIG, both DCMA and NAVAIR believe that Lockheed Martin's estimate at completion is too optimistic and that the program office will most likely require significantly more funding to complete the development program. NAVAIR provides resources to the JSF program office cost-estimating function, and it estimated in 2006 that JSF development costs could be almost $8 billion to $13 billion higher than estimated by the program office, or else cost billions more in procurement due to requirements pushed off from development. NAVAIR officials told us they believe that the 2006 estimate continues to be accurate today, but explained that since the JSF program is a joint program they do not control JSF cost-estimating procedures, although their estimates are briefed to JSF program management. The estimate removed what NAVAIR views as artificial constraints on the JSF schedule and projected forward, resulting in an estimate that the schedule would likely slip 19 to 27 months, and combined this with trends in cost performance. NAVAIR officials said that their confidence in the achievability of the JSF program schedule is low, as the master schedule comprises more than 600 individual schedules, making it difficult to accurately assess the achievability of the overall schedule.

DCMA estimates that JSF development could cost as much as $4.9 billion more than program office estimates, accounting for poor cost and schedule performance to date and assuming further schedule slips of up to 12 months. DCMA confirmed that a schedule risk analysis, which uses statistical techniques to obtain a measure of confidence in completing a program, has never been performed on the JSF program. Since historically state-of-the-art development programs have taken longer than planned, a schedule risk analysis should be conducted to determine the level of uncertainty in the schedule. Despite these outside organizations' predictions of significantly higher costs to complete the JSF contract and

the lack of realism in the contractor's own estimate, the JSF program office continues to use the contractor's estimate as its own.

Table 9: NAVAIR and DCMA Estimates at Completion for JSF Aircraft Development Contract (Then-year dollars in billions)

	Estimates	Projected overrun to the estimate
Lockheed Martin's estimate at completion (EAC)	$23.4	
NAVAIR best case EAC projection	$31.3	**$7.9**
NAVAIR worst case EAC projection	$36.8	**$13.4**
DCMA EAC based on earned value data	$24.8	
DCMA additional costs for schedule slip	$3.6	
Total DCMA EAC (earned value + schedule slip)	$28.3	**$4.9**

Source: GAO analysis of DOD data.

In addition to expected cost overruns for JSF development, the CAIG is predicting significantly higher costs for JSF for the military services to purchase the aircraft. Using different assumptions about weight growth, labor rates, avionics and propulsion costs, and contractor fees, the CAIG calculated significantly higher unit costs for the aircraft variants (see table 6 earlier in this report for comparison of CAIG and program office assumptions affecting both development and procurement costs estimates). Multiplying these higher unit costs by the expected procurement quantities leads to a more than $33 billion (in constant year 2002 dollars) difference from official program office estimates for procurement costs.[3] The CAIG estimates were briefed in 2006 to the DOD working group that oversees the JSF program, and top OSD officials were aware of the discrepancy between the CAIG and JSF program office estimates.

The program office has not conducted an uncertainty analysis on its cost estimates despite the complexity of the program and associated risk and uncertainty. As shown in table 10, the JSF program is significantly more complicated than comparable aircraft development programs.

[3] We expressed the costs in constant 2002 dollars instead of then-year dollars because the data we relied on to make this projection were in constant dollars, and we did not have the quantity profiles by year to inflate the costs.

Table 10: JSF Complexity Compared to That of Similar Aircraft Programs

Complexity factor	F/A-18E/F	F/A-22	JSF
Program participation by multiple military services	No	No	Yes
Aircraft variants	One	One	Three
Avionics	Off-the-shelf	New	New
Stealth	Minimal	Yes	Yes
Software (operational flight program source lines of code)	1.1 million	2.2 million	5.0 million[a]
Engine(s)	One	One	Two cruise, one lift
International participation	No	No	Yes

Source: CAIG

[a]This assumes approximately 30 percent growth in lines of code by completion of development (F-22 included 34 percent growth and F/A-18, 60 percent growth).

This complexity makes it all the more necessary to fully account for the effect various risks can have on the overall cost estimate. An uncertainty analysis assesses the extent to which the variability of an outcome variable is caused by uncertainty in the input parameters. It should be performed for every cost estimate in order to inform decision makers about the likelihood of success. In performing uncertainty analysis, an organization varies the effects of multiple elements on costs, and as a result, can express a level of confidence in the point estimate.

We found that the JSF program has not conducted an uncertainty analysis. Such analysis would provide a range of possible values to program management and an estimate of the likelihood of the various possibilities. Instead, the program office only offers a single point estimate—one dollar figure, with no associated range—and no technical analysis of the likelihood that this estimate is credible. The lead cost estimator for the program office acknowledged that such a single point estimate is virtually certain to be wrong, but also stated that the analysis used to develop a range of values is easily manipulated and therefore not valuable. It is GAO's view that a point estimate should be accompanied by an estimated confidence level to quantify the uncertainty surrounding the estimate in order for management to make good decisions. Because the JSF program office has not conducted an uncertainty analysis, it is unable to provide Congress with any confidence level for its point estimate of approximately $300 billion for JSF acquisition.

Appendix III: Comments from the Department of Defense

OFFICE OF THE UNDER SECRETARY OF DEFENSE
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ACQUISITION,
TECHNOLOGY
AND LOGISTICS

MAR 1 0 2008

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

Dear Mr. Sullivan:

This is the Department of Defense (DoD) response to the GAO draft report, "JOINT STRIKE FIGHTER: Recent Decisions by DoD Add to Program Risks," dated February 5, 2008 (GAO Code 120663/GAO 08-388).

The Department partially-concurs with the report's first two recommendations and concurs with the final two recommendations. The Department appreciates the GAO's highlighting of both program successes and challenges. Details of the Department's responses are contained in the enclosure.

The Department values the opportunity to comment on the draft report and looks forward to continued discussions on the Joint Strike Fighter program with the GAO for next year's audit.

Sincerely,

David G. Ahern
Director
Portfolio Systems Acquisition

Enclosure:
As stated

GAO DRAFT REPORT DATED FEBRUARY 5, 2008
GAO-08-388 (GAO CODE 120663)

"JOINT STRIKE FIGHTER: RECENT DECISIONS BY DOD ADD TO PROGRAM RISKS"

DEPARTMENT OF DEFENSE COMMENTS TO THE GAO RECOMMENDATIONS

RECOMMENDATION 1: The GAO recommends that the Secretary of Defense direct elements of the Department to revisit and, if appropriate, revise the Mid-Course Risk Reduction plan recently approved. (Page 31/GAO Draft Report)

DOD RESPONSE: Partially-Concur. The Department continues to believe the Mid-Course Risk Reduction (MCRR) plan is a cost effective approach with a manageable level of risk. USD(AT&L) approved the plan in October 2007 after thorough review of the benefits and risks. Implementation of the plan is well underway. The Department developed metrics to monitor and evaluate contractor Management Reserve replenishment and use, manufacturing line progress, and the MCRR impacts on developmental testing. The plan has always been to revisit and, if necessary, revise MCRR implementation if metrics/monitoring fail to achieve expectations. The Department does not plan to alter its current plan of monitoring MCRR execution.

RECOMMENDATION 2: The GAO recommends that the Secretary of Defense direct that the Joint Strike Fighter (JSF) program office update its cost estimate using best practices, so that the estimate is comprehensive, accurate, well-documented, and credible. Specifically, the JSF program office should:

(a) Include costs that were inappropriately omitted from the estimate;

(b) Identify performance requirements that have been traded off in development;

(c) Fully document assumptions, data sources, and methodologies in the cost model; and

(d) Perform a risk and uncertainty analysis to focus on key cost drivers and reduce the risk of cost overruns. (Page 31/GAO Draft Report)

DOD RESPONSE: Partially-Concur. The F-35 Program Office is completing a comprehensive cost estimate in preparation of an independent assessment directed by the Department of Defense, as indicated in the response to Recommendation 4. The

Department believes that a Risk and Uncertainty Analysis as defined in GAO-07-1134SP Cost Assessment Guide is unwarranted due to the subjective nature of the modeling inputs.

RECOMMENDATION 3: The GAO recommends that the Secretary of Defense direct that the program conduct a full Schedule Risk Analysis to ensure that its schedules are fully understood, manageable, and executable. (Page 31/GAO Draft Report)

DOD RESPONSE: Concur. A combined Navy, Air Force, and OSD team will consider schedule risk in a planned joint cost estimate update, discussed in more detail in the response to Recommendation 4.

RECOMMENDATION 4: The GAO recommends that the Secretary of Defense direct that a full, independent cost estimate be conducted according to the highest standards of any DoD cost estimating organization, based on a comprehensive review of program data; that this cost estimate be reviewed by an independent third party such as the Cost Analysis Improvement Group; and that the results of these estimates be briefed to all interested parties in DoD and the Congress. (Page 31/GAO Draft Report)

DOD RESPONSE: Concur. In January 2008, the Department directed an independent joint cost assessment to be performed by a team of Navy, Air Force, and OSD cost experts. This joint cost assessment was initiated at the request of the F-35 Program Executive Office (PEO) and will aid the Department's development of the FY 2010 President's Budget request.

The Department is pleased that the GAO endorses a path the PEO and OSD have already developed, i.e., a joint independent F-35 cost review. The Air Force Cost Analysis Agency (AFCAA), NAVAIR 4.2, and OSD Cost Analysis Improvement Group (CAIG) are participating in the review. We appreciate the fact that GAO recognizes the complexities involved in estimating F-35 costs.

FACTUAL DISCREPANCIES: There are three significant discrepancies noted within the report. The March 2004 re-plan added $7.5 billion to the development estimate, not "over 10 billion" dollars as indicated in the report. Additionally, the December 2006 cost estimate reflected an increase in the Military Construction (MILCON), not a reduction as GAO states. The past six annual Selected Acquisition Reports assert that MILCON estimates will continue to be updated as the Services identify specific site requirements. Lastly, GAO cites a total procurement cost increase of 28% since March 2004 but omits the fact that the increase is less than half of that (i.e., 13%) when inflation impacts are excluded.

Appendix IV: GAO Contact and Staff Acknowledgments

GAO Contact

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Staff Acknowledgments

Bruce Fairbairn, Assistant Director; Jerry Clark; Marvin Bonner; Simon Hirschfeld; Matt Lea; Karen Richey; Dave Hart; and Jim York

Related GAO Products

Joint Strike Fighter: Impact of Recent Decisions on Program Risks. GAO-08-569T. Washington, D.C.: March 11, 2008

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