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United States Government Accountability Office
Washington, DC 20548

May 22, 2006

The Honorable John Warner
Chairman
Committee on Armed Services
United States Senate

The Honorable Curt Weldon
Chairman
Subcommittee on Tactical Air and Land Forces
Committee on Armed Services
House of Representatives

Subject: Tactical Aircraft: DOD's Cancellation of the Joint Strike Fighter Alternate Engine Program Was Not Based on a Comprehensive Analysis

The Department of Defense (DOD) expects to purchase about 2,400 Joint Strike Fighter (JSF) aircraft, with potential international sales of 2,000 to 3,500 aircraft. When the number of aircraft engines and spare parts expected to be purchased is considered—along with the lifetime support needed to sustain the engines—the future financial investment will be significant. DOD implemented the JSF alternate engine development program in 1996 to provide competition between two engine manufacturers in an effort to achieve cost savings, improve performance, and gain other benefits.

Since then, DOD has invested \$1.2 billion in the alternate engine program, and, in August 2005, it awarded a \$2.4 billion contract for system development and demonstration of an alternate engine. However, in its fiscal year 2007 budget submission, DOD proposed canceling the alternate engine program. Concerned whether this decision was based on sound analysis, you asked us to review DOD's rationale for canceling the program and the analysis supporting it, including the life cycle savings, benefits, and risks assessed.

To determine DOD's rationale for and analysis supporting the decision to cancel the alternate engine program, we obtained and discussed data from the Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics; the Office of the Director of Program Analysis and Evaluation; and Air Force and Navy acquisition offices. We also interviewed officials from the Office of the Director, Operational Test and Evaluation, and the F-22A engine office, the predecessor engine for the JSF engine. We reviewed the data, analyses, assumptions, and results of two prior

program management advisory group studies¹ and the justification briefing provided to Congress by the department. The advisory group studies and briefing were identified as the analytical underpinnings of the decision. We also met with the Air Force executive who co-led both advisory groups and was the Air Force's propulsion product group manager. Finally, the JSF program office stated that it was not involved in the termination proposal. In performing this review, we used data and information from that office collected on other assignments. We performed our review from March to April 2006 in accordance with generally accepted government auditing standards.

SUMMARY

DOD's decision to cancel the JSF alternate engine program was driven by the need to identify sources of funding in order to pay for other priorities within the department. In making the decision, the department did not conduct a new and comprehensive analysis, but instead relied on selective elements of two prior studies done in 1998 and 2002. In supporting the decision to cancel, officials focused only on the potential up-front savings in engine procurement costs. They did not, however, consider the full long-term savings that might accrue from competition for providing support for maintenance and operations over the life cycle of the engine. Both prior studies had recommended proceeding with the alternate engine program, despite the lack of significant procurement cost savings, because of a number of other benefits competition was likely to provide. Also in supporting the decision to cancel, officials cited favorable progress made by the primary JSF engine and its predecessor F-22A engine as reducing operational risks from a single source. However, the primary JSF engine has completed only a small portion of its ground tests and has not yet been flown, while the F-22A engine has completed about 10 percent of its hours needed for system maturity and is not currently meeting some reliability goals. Further, experts from one early study concluded that the commonality with the F-22A engine is of limited benefit for reducing development risk of the JSF engine.

DOD'S RATIONALE FOR TERMINATING THE ALTERNATE ENGINE PROGRAM

The decision for canceling the JSF alternate engine program was driven by budget needs outside the JSF program. The decision was a consequence of budget-cutting exercises to meet Office of the Secretary of Defense (OSD) spending targets and to begin implementing Quadrennial Defense Review (QDR) decisions. The alternate engine program was deemed to have a lesser priority than other major DOD activities and programs. DOD officials and the justification briefing stated that the rationale for canceling the program was no net cost savings from competing engine buys and minimum operational risk from relying on a single source.

¹ Advisory groups composed of DOD and foreign partner representatives from the technical, operational, and financial communities were established under the aegis of the Assistant Secretary of the Navy for Research, Development, and Acquisition to review technical and programmatic issues of the alternate engine program, determine its costs and benefits, and make recommendation for either continuing or terminating the program.

Funding for the alternate engine was included in the Navy's and Air Force's initial 2007 budget submissions, according to the services' acquisition officials. However, because of budget constraints, OSD directed the military services to identify alternative sources for reducing the fiscal year 2007 future years defense budget. Both services proposed the termination of the alternate engine program. DOD officials estimated that canceling the program would result in savings of about \$2 billion over the remaining 8 years of the alternate engine development program, which could then be used to fund higher-priority programs. In recent testimony, the Under Secretary of Defense for Acquisition, Technology, and Logistics stated that the department ultimately concluded that maintaining two engine suppliers for the JSF program was not the most efficient use of its resources. Department officials also noted that the primary engine development program was progressing well, making a second engine program unnecessary. On the basis of its assessments of the progress of the primary engine for the JSF, the F-22A engine (which served as the basis for the primary JSF engine), and past fighter engine experience, officials deemed operational risks associated with a single engine supplier acceptable.

DOD'S DECISION TO CANCEL THE ENGINE COMPETITION WAS BASED ON INSUFFICIENT COST, SAVINGS, AND PERFORMANCE DATA

DOD did not conduct an up-to-date, comprehensive analysis of the total life cycle costs, savings, and benefits to support its decision to terminate the JSF's alternate engine development program. Instead, DOD officials used two prior studies and considered the savings from engine procurement only, excluding potential life cycle cost savings associated with supporting, operating, and maintaining the fleet. These officials also stated that the operational risk from relying on a single supplier is reduced by favorable test and operational experiences with the primary JSF and F-22A engines. However, this assessment is based on:

- limited ground testing of the primary JSF engine and no actual flight test results;
- experience with the F-22A engine, which has only completed about 10 percent of the operational flight hours needed to achieve system maturity and which has still not achieved its reliability goal; and
- comparisons with the F-22A engine, which will likely have different operational uses than the JSF engine.

DOD's Decision Is Not Supported by a Current and Comprehensive Analysis of Costs and Benefits

DOD officials stated that the decision to cancel the JSF alternate engine program is based largely on studies conducted in 1998 and 2002 by program management advisory groups. These groups recommended that DOD proceed with the alternate engine program, noting that the recommendation was made independent of the services' abilities to fund the program. The advisory groups determined that developing an alternate JSF engine had significant benefits in the areas of contractor responsiveness, industrial base, readiness, and international relations. They also reported finding marginal benefits in the areas of cost savings and additional engine

growth capabilities (ability to add future engine improvements), and no benefit to reducing development risk without restructuring the program. Table 1 provides a summary of the program management advisory group study results.

Table 1: 1998 and 2002 Program Management Advisory Group Study Findings on the Benefits of an Alternate Engine Program

| Factor assessed | Beneficial | | Marginal | | No value | |
|-----------------------------------|------------|----------|----------|------|----------|------|
| | 1998 | 2002 | 1998 | 2002 | 1998 | 2002 |
| Costs | | | x | x | | |
| Development risk reduction | | | | | x | x |
| Engine growth potential | | | x | x | | |
| Fleet readiness | x | x | | | | |
| Industrial base | x | x | | | | |
| International implications | x | x | | | | |
| Other considerations ^a | x | x | | | | |
| Overall | x | x | | | | |

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

^a Other considerations include contractor responsiveness, improved design solutions, and competition at the engine subsystem level.

DOD’s current conclusion that net savings from an alternate engine program would be negligible at best was largely based on a break-even analysis in the 2002 study that calculated how many engines would need to be purchased at prices reflecting savings from competition to recover the costs incurred to develop the second source. The analysis used the total projected costs of the alternate engine development program, an estimated \$2.8 billion at that time.² However, DOD has now invested about one-third of that total since the 2002 study. Excluding these sunk costs and basing the break-even analysis on development costs to go from this point forward would reduce the engine costs that would need to be recovered through cost savings associated with ongoing competition between engine suppliers. For example, on the basis of the estimated development costs to go and using the same assumptions and data as the 2002 study, we estimate that achieving 20 percent savings from competition would allow a break-even point to occur at about 1,700 engines—not 2,500, as projected in the 2002 study. An earlier break-even point in the purchase of engines would increase the potential for savings over the life of the program.

Officials indicated that DOD’s decision did not consider all the costs and savings over the projected 30-year life cycle of the weapon system. A life cycle cost-benefit analysis would consider all the potential costs and savings associated with the competition, including operations and support, over the expected life of the system. DOD did not analyze the potential impact that a second supplier and supply chain could have on long-term support costs for buying spares, engine parts, and maintenance services. Given that a large percentage of a fighter aircraft’s total life cycle costs are incurred after it has been acquired and fielded, potential savings from competition could be significant. Competition could also yield savings through reliability improvements. The 1998 study stated that a 10 percent improvement in

²Dollars are fiscal year 2002 constant for comparison with the 2002 DOD break-even analysis.

reliability could allow the user to omit one heavy maintenance cycle of the engine, saving \$3 billion in operating and support costs, and concluded that the costs for developing the alternate engine would likely be recovered through production and operational cost savings. The 2002 study did not quantify potential operations and support savings, but supported the earlier study's conclusions on the benefits from competition.

Finally, DOD officials indicated that the decision to cancel the engine competition did not fully consider the other, less quantifiable benefits that were strongly considered by the program management advisory groups in recommending the continuation of the program in 1998 and 2002. These studies concluded an alternative engine program would

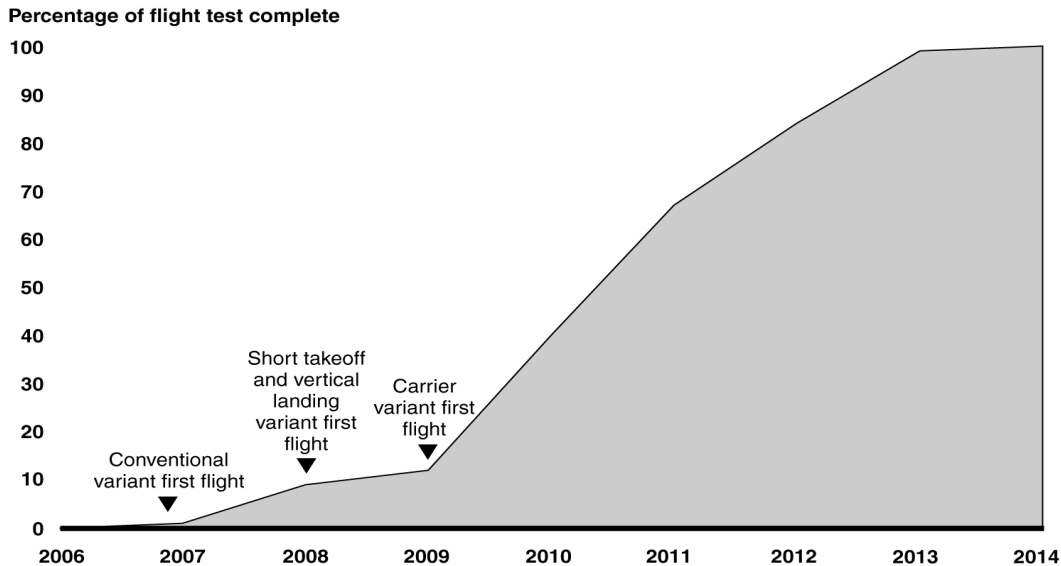
- maintain the industrial base for fighter engine technology,
- enhance readiness,
- instill contractor incentives for better performance,
- ensure an operational alternative if the current engine developed problems, and
- enhance international participation.

Many of these were important benefits realized by past competitions such as that for the Air Force's F-16 engines. While these benefits are difficult to quantify, the Air Force engine manager who co-led both advisory group studies explained that they are valuable when trying to manage significant numbers of fighter-type engines to ensure combat readiness. He told us that problems are magnified when trying to manage a single engine system, which can require substantial manpower and extra hours to keep aircraft flying when engine problems occur. In his opinion, the benefits of a dual-source engine would outweigh the costs. He stated that he had not seen anything that would change this conclusion since the last advisory group study was conducted.

More Engine Performance Data Are Needed to Reduce Operational Risks

Despite DOD officials' assertions that testing to date has reduced risks, there has not been sufficient testing to demonstrate that the primary JSF engine will perform as expected. At the time of the decision to cancel the alternate engine, the primary JSF engine had only completed about 4,600 hours of ground tests—about one-third of the hours planned—and had not yet been flight-tested in a JSF aircraft. The first flight of the conventional takeoff and landing variant aircraft is not expected until October 2006. First flight of the short takeoff and vertical landing variant is scheduled for early 2008, and the carrier variant in early 2009. The first dedicated operational testing that will measure the JSF's operational effectiveness and suitability is scheduled for 2011. Specific propulsion flight testing starts out slowly and begins to increase significantly beginning in 2009 (see fig. 1).

Figure 1: Planned Propulsion Performance Flight Testing and First Flights for the Three JSF Variants



Source: GAO analysis of DOD testing data.

The maturity of the JSF engine is also reflected in the program’s contract strategy, in which initial production orders for the JSF engines will be on a cost reimbursement basis. This type of contract is used when the uncertainties involved in contract performance do not permit costs to be estimated with sufficient accuracy to use any type of fixed-price contract. This places the risk from the uncertainties with the buyer—in this case, DOD. The program plans to transition to fixed-price-type contracts for the engine when processes stabilize and the system matures, sometime before full-rate production begins in 2013. This will shift more risk to the contractor.

DOD officials also cite the good performance to date of the F-22A engine as reducing the risk from relying on a single source, but this argument has several qualifications. First, although the JSF primary engine is a derivative of the F-22A engine, the F-22A has completed only about 20,000 operational engine hours; this represents about 10 percent of the 200,000 hours considered sufficient for system maturity. F-22A program engine officials noted that while overall performance has been good, the F-22A engine is currently not meeting several reliability goals. For example, the engine’s mean time between maintenance actions was expected to be 100 hours on average at its initial service release in 2002. However, as of April 2006, the engine was experiencing an average of 60 hours between maintenance actions. The program projects that at system maturity in 2010, the F-22A engine mean time between maintenance actions will be about 100 hours, but that is only 50 percent of its performance requirement for 200-hour mean time between maintenance actions. Officials also cited four other reliability goals, two that are currently being met and two that are not being met.

Second, the two aircraft have different missions and operational concepts that may produce different stresses on the engines. The single-engine JSF aircraft is being designed to rapidly transition between different air-to-surface and air-to-air missions while still airborne. The JSF aircraft design has three variants, each with a different operational concept. In contrast, the dual-engine F-22A will primarily be an air-to-air fighter that will fly at high speed and high altitude. Both test and engine officials stated that the operational environment for the JSF may put more stress on the plane's engine than the operational environment for the F-22A puts on its engine. According to engine officials, the fact that the JSF relies on a single engine for its performance magnifies any potential problems that it may incur and increases the maintenance needed to sustain its readiness.

Third, the 1998 study stated there was limited commonality between the F-22A engine and the JSF engine configurations and for that reason there was limited reduction in development risk achieved from F-22A experience. The study stated the development risk for the JSF engine was commensurate with a new fighter engine, and of particular concern were the high temperature and short takeoff and vertical landing integration requirements. Engine and acquisition officials we talked to had differing views on the degree of commonality between the two engines and impacts on development risk. We note that the development effort on the JSF primary engine is expected to cost \$5.8 billion, indicating a substantial development effort.

CONCLUSIONS

The relative advantages and disadvantages of the JSF alternate engine program can change significantly depending upon the factors assessed and considered. In deciding to terminate the program in 2007, DOD did not conduct a current and comprehensive study of the costs and benefits of the alternate program. It relied on selected elements of two older studies that reviewed the JSF alternate engine program in 1998 and 2002. It focused on the estimated savings to be accrued from the reduced price to buy engines based on competition between two sources. It did not consider the benefits, including potential cost savings, that might be derived from competition during the life of the JSF program—future engine buys, spare parts, maintenance, reliability improvements, support improvements, industrial base benefits, and other longer-term factors. The two prior studies both concluded that these benefits would be substantial and sufficient reason to continue the program. In addition, the decision was based on a break-even analysis for the total investment cost (sunk costs as well as costs to go) of the alternate engine program. Sunk costs should be excluded from the break-even analysis upon which the decision is based, thereby lowering the number of engines required to break even. In deciding to cancel the competition, DOD determined that it could not afford this program, given other needs in DOD and the government. It had to find money for other budget priorities, and the alternate engine program was not accorded a high enough priority. The question remains whether a more current, comprehensive, and independent study including all costs, benefits, and risks—not just up-front procurement costs—would result in a different answer that would cause DOD to reconsider its decision to cancel the

alternate engine program and instead afford it a higher priority and cause it to continue the JSF engine competition.

AGENCY COMMENTS AND OUR EVALUATION

DOD provided us with written comments on a draft of this report. The comments appear in the enclosure to this letter.

In summary, DOD believes the report is misleading in a number of respects in that there are many important issues that deserve more thoughtful and balanced consideration than the information presented in our report. It highlights these in its comments, which include its beliefs that (1) data showing savings from competition do not exist and (2) certain higher costs would exist if the competitive alternate engine program continued. We agree that there is a mix of factors that can increase and decrease costs as well as influence readiness and the industrial base. However, as pointed out in DOD comments, there is currently a paucity of empirical data about the costs and benefits of this program; therefore we think the issues raised by DOD in its letter need to be considered within an overall and comprehensive analysis of the life cycle costs and benefits of a competitive alternate JSF engine program.

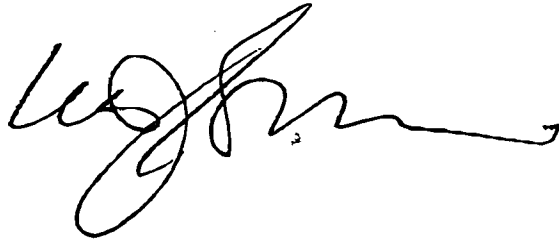
Our tasking, from both the Senate Armed Services Committee and the House Armed Services Tactical Air and Land Forces Subcommittee, was to review DOD's rationale for canceling the program and the analysis supporting that decision. It was not our tasking to perform the analysis for DOD. Our conclusions were that DOD had not conducted a current and comprehensive study of the costs and benefits of an alternate engine program over the entire life of the JSF. Instead of undertaking a new study, DOD relied on selective elements of two older studies, both of which concluded that significant benefits, beyond price savings in the acquisition program, justified continuing the alternate engine program. DOD supported and funded the alternate engine program in prior years but now believes the program is not cost-beneficial and presents a low risk if canceled. We found that the affordability pressures caused by other more pressing demands on the DOD budget this year caused DOD to look for sources of funding. As a result, DOD viewed the alternate engine program as a lesser priority within the agency.

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We are sending copies of this letter to the Honorable Donald H. Rumsfeld, Secretary of Defense; the Honorable Michael W. Wynne, Secretary of the Air Force; and the Honorable Donald C. Winter, Secretary of the Navy. We will make copies available to other interested parties upon request. The letter is also available at no charge on the GAO Web site at <http://www.gao.gov>.

Please contact me at (202) 512-4841 if you or your staffs have any questions. Contact points for our offices of Congressional Relations and Public Affairs may be found on the last page of this report. Other major contributors to this letter were Mike Hazard, Matt Lea, Bruce Fairbairn, and Gary Middleton.

Sincerely yours,

A handwritten signature in black ink, appearing to read "Michael J. Sullivan". The signature is fluid and cursive, with a large initial "M" and "S".

Michael J. Sullivan, Director
Acquisition and Sourcing Management

Enclosure

Enclosure

Comments from the Department of Defense



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MAY 16 2006

Mr. Michael J. Sullivan
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Dear Mr. Sullivan:

This is the Department of Defense (DoD) response to the Government Accountability Office (GAO) Draft Report, "Tactical Aircraft: DoD's Cancellation of the Joint Strike Fighter Alternate Engine Program Was Not Based on a Comprehensive Analysis" dated May 5, 2006 (GAO Code 120548/GAO-06-717R).

The GAO offered no recommendations; however, the Department would like to provide a written response (enclosure).

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

Sincerely,


Mark D. Schaeffer
Acting Director
Defense Systems

Enclosure:
As stated



GAO DRAFT REPORT - DATED MAY 5, 2006
GAO CODE 120548/GAO-06-717R

**"TACTICAL AIRCRAFT: DoD's Cancellation of the Joint Strike Fighter
Alternate Engine Program Was Not Based on a Comprehensive Analysis"
(GAO Code 120548)**

DEPARTMENT OF DEFENSE (DoD) COMMENTS

In examining the JSF second engine supplier issue, GAO's draft report to Senator Warner was misleading in a number of respects and left out important information that runs counter to the draft report conclusions.

The draft report concluded that the Department of Defense did not conduct a current and comprehensive analysis of the costs and benefits of maintaining two engine suppliers. Central to this argument was the claim that DoD focused on the high investment and procurement costs of establishing two suppliers and did not examine the "full long-term savings which might accrue from competition. . . ." The draft report's argument would lead one to believe that there are data providing evidence of Operations and Support (O&S) savings from competition when, in fact, such data do not exist.

We do know that some O&S costs will be *higher* with two suppliers of engines—a fact not mentioned in the draft report to Senator Warner. Although the Pratt & Whitney and General Electric engines are designed to have identical external interfaces to the aircraft, making them interchangeable, the two internal designs are significantly different. Most of the engine parts are unique, including the fans, turbines, combustors, and compressors. Use of the two types of engines would require establishing two separate spares pipelines for fleet and depot-level maintenance, providing additional training and tools for maintenance personnel, creating two separate depot capabilities (thereby increasing non-recurring costs and recurring unit repair costs since each repair line would handle fewer units), and making future modifications for growth, reliability improvements, safety enhancements, and obsolescence management on two different engines.

The draft report critiques DoD for not considering the O&S savings from buying engine spares from two suppliers instead of one supplier. This argument, also used in testimony by GE Aviation President and CEO Scott Donnelly, is misleading. Engine spares are not purchased in a competitive environment, since, for example, DoD would not buy spares made by Pratt & Whitney to support the GE engine. Therefore, we do not expect competition to significantly affect the price of engine spare parts.

Enclosure

If we do face engine problems in the future, we believe that fixing any problems with the original engine will cost less than developing and producing a second engine (which might develop its own unique problems). To date, the performance of the Pratt & Whitney engine has been excellent, giving us confidence in its reliability. The 2002 RAND study, *Military Jet Engine Acquisition*, noted the key performance requirements that led all three contractors to select the F119 derivative were “very high reliability for the single-engine Navy JSF variant and sufficient non-augmented thrust for the short takeoff and vertical landing JSF variant.”

The draft report does not mention why it is so difficult to achieve a net cost savings from engine competition, despite considerable discussion on this point with DoD officials. In addition to the upfront *development* cost of at least \$2.4 billion, several key factors work to increase *procurement* costs. Producing a given amount of engines with two suppliers instead of one supplier reduces the advantage from “learning curve” effects (whereby costs decrease as a company produces more units) and from “rate effects” (whereby fixed costs are spread over production units). Our experience with the F404 engine in early-model F/A-18s illustrates the point; the average unit costs of this engine did not decrease after competition was introduced.

Finally, the draft report mischaracterizes DoD’s rationale for terminating the alternative engine program. The draft report states, “The alternative engine program was deemed to have a lesser priority than other major DoD activities and programs.” A more accurate description would address DoD’s process of weighing the upfront costs of paying for a second supplier against the risk of relying on a single engine supplier. While DoD recognizes that there are benefits to having two engine sources, the risk of a single engine supplier for JSF was judged manageable compared to other risks the Department faces.

In summary, GAO’s draft report to Senator Warner focuses on benefits that cannot be supported by empirical data. The draft report criticizes DoD for ignoring O&S savings but does not specify what those savings are, how they might be achieved, and how they would outweigh the known costs—in investment, procurement, and O&S—of maintaining two engine suppliers. We hope you’ll agree that this response raises important issues that deserve more thoughtful and balanced consideration in your draft report.

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