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United States Government Accountability Office  
Washington, DC 20548

September 15, 2010

The Honorable Carl Levin  
Chairman  
Committee on Armed Services  
United States Senate

Subject: *Joint Strike Fighter: Assessment of DOD's Funding Projection for the F136 Alternate Engine*

Dear Senator Levin:

The Joint Strike Fighter (JSF) program began in 1996 with an acquisition strategy that called for a competitive engine acquisition program. The program planned to first develop and procure the F135 primary engine and, with a few years lag time, develop the F136 second (or alternate) engine to compete with the F135 engine for future procurements and life-cycle support activities. The Department of Defense (DOD) requested funding for both engines annually as the JSF program progressed until the fiscal year 2007 budget submission, at which point the DOD stopped requesting funding for the F136 alternate engine. Defense officials believe that the operational risks of relying on a single engine supplier are low and do not justify the extra costs to maintain a second engine source. DOD further states that there is no guarantee that having an engine competition will create enough long-term savings to outweigh the up-front costs and now intends to acquire only the F135 primary engine. However, Congress has continued to fund the alternate engine development program annually through fiscal year 2010.

According to the Secretary of Defense, DOD would need an additional \$2.9 billion in funding over the next 6 years to support an alternate engine program up to the point where it believes it could begin competition in 2017. This amount includes the additional funding DOD says is needed with respect to the alternate engine to finish system development and demonstration, allow sufficient time for the contractor to gain production experience before DOD begins the competition,<sup>1</sup> and create a logistics support system for the engine. DOD has stated that it has higher priority

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<sup>1</sup> This refers to a period of time for noncompetitive procurement of both engines, providing the alternate engine contractor an opportunity to gain production experience and learning before DOD begins competitive engine procurements.

# Report Documentation Page

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needs for this funding and has not included any funding in its fiscal year 2011 budget request for the alternate engine.

At your request, we reviewed the basis for DOD's \$2.9 billion funding projection and its key assumptions. We obtained and discussed data from the Office of the Secretary of Defense's Cost Analysis and Program Evaluation office, including its assumptions and methods used in formulating the estimate. We reviewed DOD's 2007 cost analysis of the JSF alternate engine program and its 2010 update. In performing our review, we used data and information collected over the past several years from our body of work reviewing the overall JSF and alternate engine programs.<sup>2</sup> We also relied on guidance provided in the March 2009 *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs*. We performed our review from July 2010 to September 2010 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.

## **SUMMARY**

The \$2.9 billion funding projection cited by DOD as the additional funding required to support an alternate engine program was intended to provide a general sense of the funding needed. As such, the projection does not include the same level of fidelity and precision normally associated with a detailed, comprehensive estimate. DOD analysts relied largely on data, assumptions, and methodologies from an analysis done 3 years ago and have characterized the \$2.9 billion projection as having an equal chance of being too high or too low. Therefore, this projection should be viewed as one point within a range of possible costs depending on the factors and assumptions used, and not as an absolute amount.

Different assumptions and more detailed information could either increase or decrease the \$2.9 billion funding projection. That said, we found two key assumptions made by DOD in developing the \$2.9 billion funding projection that have a significant impact on the estimated amount of upfront investment needed. These assumptions were (1) 4 years of noncompetitive procurements of both engines would be needed to allow the alternate engine contractor sufficient time to gain production experience and complete developmental qualification of the engine, and (2) the government would need to fund quality and reliability improvements for engine components. Past studies and historical data we examined indicate that it may take less than 4 years of noncompetitive procurements and that competition may obviate

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<sup>2</sup> Our latest testimony on this subject is GAO, *Joint Strike Fighter: Significant Challenges and Decisions Ahead*, GAO-10-478T (Washington, D.C.: Mar. 24, 2010).

the need for the government to fund component improvement programs. If these conditions hold true for the alternate engine, the funding projection for the alternate engine could be lower than DOD’s projection.

**DOD’S ALTERNATE ENGINE COST PROJECTION IS NOT A DETAILED, COMPREHENSIVE ESTIMATE**

DOD projected that it would need \$2.9 billion of additional funding to support the alternate engine program to the point where DOD believes it could begin competition in 2017. The projection was not based on, nor intended to be, a detailed, comprehensive estimate. DOD cost analysts stated the projection provides a general-level sense of the budget required to put the alternative engine on a competitive level with the primary engine. The analysts noted that DOD was in the midst of a complex and comprehensive restructuring of the total JSF acquisition program and they were unable to invest the time or resources that normally would be part of a more detailed, comprehensive estimate. Accordingly, they relied largely on data, assumptions, and methodologies from their 2007 analysis. Using the *GAO Cost Estimating and Assessment Guide*, DOD’s estimate would be characterized as a “rough order of magnitude” cost analysis. This type of analysis is typically developed when a quick estimate is needed and limited information is available, and does not include the same level of fidelity and precision normally associated with a detailed, comprehensive cost estimate. Table 1 summarizes DOD’s projection of additional development and procurement costs to enable JSF engine competition.

**Table 1: DOD’s Projection of the Additional Funding Needed to Support the Alternate Engine Program (in millions of then-year dollars)**

	Additional funding projected by DOD (FY 2011-FY 2016)
<b>Development total</b>	<b>\$1,533</b>
• System Development and Demonstration	1,188
• Engine Component Improvement Program	345
<b>Procurement total</b>	<b>1,381</b>
• Noncompetitive procurement of engines (including spares)	747
• Production tooling	133
• Support	500
<b>Total</b>	<b>2,914</b>

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

Note: Some numbers may not add because of rounding.

The following examples help illustrate the level of fidelity and precision of the information used in formulating DOD’s \$2.9 billion funding projection:

- DOD’s F136 system development and demonstration cost projection, primarily developed in 2007, is based largely on historical analogy to the development of other fighter engines with some limited updating of data. DOD analysts emphasize that they did not conduct a detailed, fact finding effort to assess the current status and costs of the F136 development for their current projection.
- DOD’s analysts chose to be methodologically consistent with their 2007 analysis and assumed competition would not begin until after JSF system development was complete. This would delay the start of competition by 3 years, from 2014 to 2017. At the time the 2007 study was done, the overall JSF system development program and F136 development efforts were scheduled to be complete at about the same time. However, since that time, the JSF development program has slipped about 3 years while projected completion of F136 engine development has slipped about 7 months.
- DOD’s procurement cost projection did not use actual production cost data for either the F135 or F136 and relied on historical data from the F119 engine used on the F-22. DOD’s analysis also assumed the initial F136 engine procurement unit prices would be the same as the F135’s initial unit prices, and that both engines would follow the same price curve. We note that the F136 engine is a different design and the contractor will likely use different manufacturing processes. In addition, the F136 engine development began 3 to 4 years after the F135 engine development and may benefit from F135 lessons learned and flight test results.
- To project support costs for the alternate engine, the analysts applied a historical cost factor of 21 percent to the estimated F136 flyaway procurement costs for fiscal years 2013 through 2016, and then equally divided the amount over this same time period for an estimated “level of effort.”
- DOD’s analysis did not take into account \$70 million of appropriated but unobligated F136 engine procurement funding that could potentially be used to offset some of the projected costs.

Different assumptions and more detailed information could either increase or decrease the \$2.9 billion funding projection accordingly. DOD analysts have characterized the projection as being at a 50 percent confidence level—meaning that it is equally likely to be too low as too high. In addition, the DOD analysts stated that they did not conduct a sensitivity analysis that looked at different scenarios with alternative assumptions, uncertainty, and risks levels, instead choosing to stay largely consistent with their 2007 analysis. Based on the *GAO Cost Estimating and Assessment Guide*, providing decision makers with a range of costs around a point estimate would be more useful, particularly when information on cost, schedule, and technical risks is limited. DOD believes any additional costs for continuing the alternate engine program are an unwarranted use of resources and that conducting a sensitivity analysis would not fundamentally change that position.

## **TWO KEY ASSUMPTIONS SIGNIFICANTLY AFFECT PROJECTED FUNDING NEEDS**

Two key assumptions made by DOD in developing the \$2.9 billion funding projection have a significant impact on the estimated amount of up-front investment needed. These two assumptions alone account for more than one-third of DOD's projection. First, DOD's funding projection reflects the assumption that 4 years of noncompetitive annual procurements of both engines are needed to allow the alternate engine contractor sufficient time to gain the production experience and learning necessary for competitive procurement and to complete developmental qualification of the alternate engine. DOD estimates additional costs of \$747 million to the U.S. government for procuring both primary and alternate engines (including spares) over these four years.<sup>3</sup> Second, DOD assumes that \$345 million of additional funding will be required through fiscal year 2016 to maintain the alternate engine's currency and improve its reliability once fielded. However, if different assumptions are made, such as (1) competition beginning 2 years earlier than DOD assumes, and (2) competition driving increased quality and reliability into the contractors' designs and processes reducing the need to fund engine component improvement programs,<sup>4</sup> the amount of additional funding to support the alternate engine program could potentially be lower.

### Amount of Time Needed for Noncompetitive Procurements

Some period of noncompetitive procurements of both engines may be needed to ensure that the alternate engine has a mature design and can be efficiently produced, but how long a period can be debated. The 4 years assumed by DOD may not all be necessary. Historical data provided by DOD show that during the "Great Engine War,"<sup>5</sup> the price of the alternate contractor's engine actually became competitive with the price of the initial contractor's engine after only 1 year of noncompetitive procurements. Assuming 2 years of noncompetitive procurement of JSF engines instead of 4 years could significantly reduce DOD's projection of \$747 million because competition would start 2 years sooner (see fig.1).<sup>6</sup>

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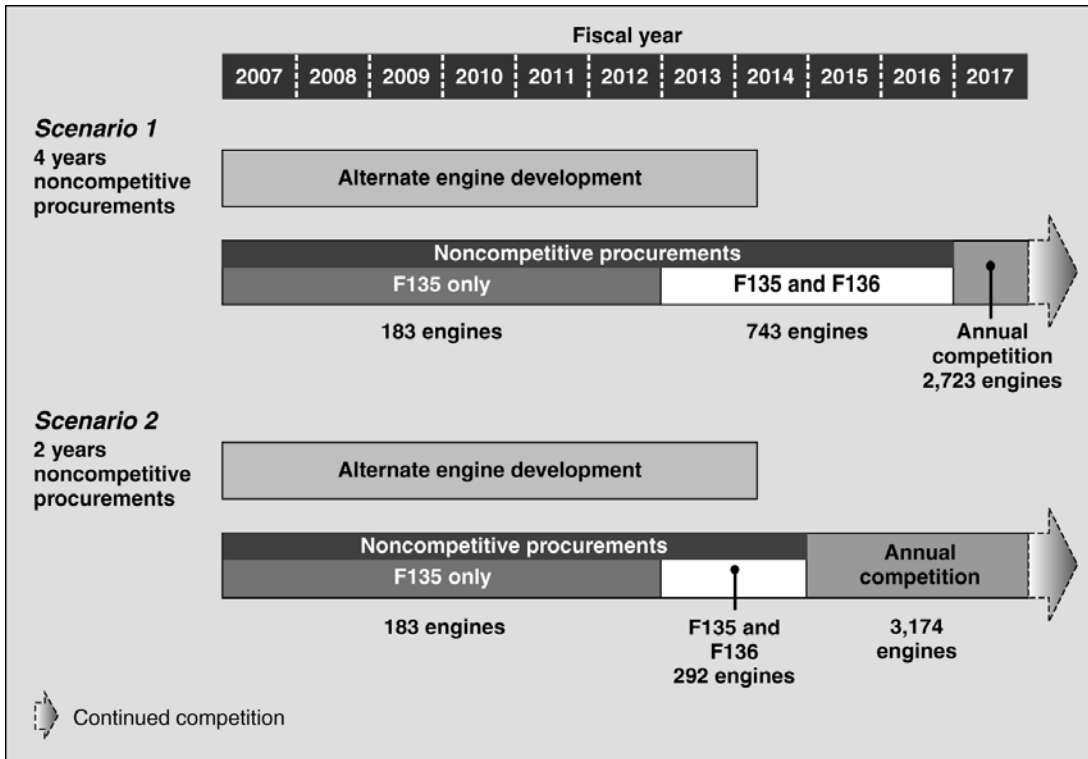
<sup>3</sup> According to DOD officials, noncompetitive procurements reduce the number of engines any one contractor would produce, affecting manufacturing efficiencies and increasing prices for both during the period that DOD buys the engines noncompetitively.

<sup>4</sup> Engine component improvement programs typically begin with the delivery of the first production engine and are intended to improve engine component quality and reliability, and resolve problems encountered after the engines are fielded.

<sup>5</sup> The competition between Pratt & Whitney and General Electric to supply military engines for the F-16 and other fighter aircraft programs which began in the 1980s is known as the "Great Engine War."

<sup>6</sup> DOD estimated that a total of \$317 million in additional U.S. government funding would be needed to procure F135 and F136 engines and initial spares through the last 2 years of noncompetitive procurements (fiscal year 2015 and fiscal year 2016).

**Figure 1: Comparison of 4-Year and 2-Year Noncompetitive Procurement Options**



Source: DOD (data), GAO (analysis).

Note: Based on the number of U.S., international, and spare engine procurements used in DOD's analysis.

Given the alternate engine contractor's current schedule, 2 years of noncompetitive procurements could still allow sufficient time to complete the alternate engine development and qualify the engine. According to DOD analysts, they did not assess any scenarios other than 4 years of noncompetitive procurements, but stated that they believe a scenario in which there is less than 4 years would require the alternate engine provider to accept more risk in order to offer a competitive price.

### Funding for Engine Component Improvements

Competition could drive increased quality into the contractors' designs and processes, and decrease or eliminate the need for DOD to fund component improvement programs for both engines. A key tenet of competition identified in studies on competition benefits is that it typically results in increased contractor responsiveness and technological innovation leading to better and more reliable products. A 2002 program management advisory group study examined the JSF alternate engine program and concluded that competition has the potential to incentivize the F135 and F136 contractors to invest their own resources in durability and reliability improvements, thereby eliminating or offsetting the need for

government-funded component improvement programs. Also, the Great Engine War was able to generate significant benefits because competition gave contractors an incentive to improve designs and reduce costs during production and sustainment. If these benefits of competition are assumed, as much as \$345 million of DOD's projected \$2.9 billion up-front costs projected for a F136 component improvement program through 2016 could potentially be eliminated. Similarly, funding currently planned for the F135 component improvement program through fiscal year 2016 could become available to further offset the additional cost projected to support the F136 engine program. According to DOD analysts, they did not assume that competition would result in both significant price decreases and improved product quality. While they agree that competition could motivate the contractors to invest their own resources to improve product quality, they assumed that the contractors would also increase their engine unit prices to cover the additional investment.

## **AGENCY COMMENTS AND OUR EVALUATION**

DOD provided us written comments on a draft of this report (enclosed). In its comments, DOD further explains the rationale for the assumptions and methods it used in developing its projection. DOD also cites our previously-reported concerns about excessive concurrency with the JSF aircraft program as indirectly supporting its assumption that 4 years of non-competitive procurements are needed for the alternate engine. Our concerns, however, have focused on the degree of concurrency with the overall JSF aircraft program, not with the F136 alternate engine program specifically. We note that the projected completion of the JSF aircraft development program has slipped about 3 years while projected completion of F136 engine development has slipped about 7 months. Therefore, we believe the risks of concurrency in this situation would be considerably lower than that of the overall JSF program.

Also, DOD comments that our analysis focused solely on describing factors that could drive alternate engine funding requirements lower than its projection and that we were generally silent with respect to a number of plausible scenarios where costs could be higher. DOD believes this may mislead readers to assume that the \$2.9 billion is at the high end of the range of possible funding needs, which it states is not the case. We do point out in our report that different assumptions and more detailed information could either increase or decrease the funding projection accordingly. The two key assumptions we highlight in our report—the number of years of noncompetitive procurements and the need for government funded component improvement programs—are examples where past studies and historical data provide evidence that the funding requirements could be lower than DOD's projection. In its comments, DOD agrees that there are a number of plausible scenarios that could impact its projection and reiterates that it is equally likely that their \$2.9 billion projection will be either too high or too low, but does not provide a potential range of how high or low. As result, we believe DOD's \$2.9 billion projection should be

viewed as one point within a range of possible costs. Given the number of plausible scenarios and the limited amount of data available, providing a range of costs, which include the consideration of different assumptions, uncertainty and risk levels, may be more useful to decisionmakers.

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We are sending copies of this report to the Secretary of Defense; Secretary of the Air Force; Secretary of the Navy; and Director of the Office of Management and Budget. The report is also available at no charge on the GAO Web site at <http://www.gao.gov>.

If you or your staff have any questions about this report, please contact me at (202) 512-4841 or [sullivanm@gao.gov](mailto:sullivanm@gao.gov). 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 were Bruce Fairbairn, Matthew Lea, and Travis Masters.

Sincerely yours,

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

Michael J. Sullivan, Director  
Acquisition and Sourcing Management

Enclosure

Enclosure

**Comments from the Department of Defense**



COST ASSESSMENT AND  
PROGRAM EVALUATION

OFFICE OF THE SECRETARY OF DEFENSE  
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WASHINGTON, D.C. 20301-1800

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, GAO-10-1020R, Joint Strike Fighter: Assessment of DoD's Funding Projection for the F136 Alternate Engine, dated September 15, 2010 (GAO Code 120927).

Thank you for the opportunity to review this draft report. We understand that your report contains no recommendations and therefore DoD comments are optional; however, we would like to take this opportunity to comment on your findings. Our detailed response is enclosed.

I appreciate the healthy dialogue and interaction between our staffs. It is an important element of providing visibility and transparency into critical national security topics such as this.

A handwritten signature in black ink, appearing to read "Christine H. Fox", is positioned above the printed name.

Christine H. Fox  
Director

Enclosure:  
DoD Comments to GAO Draft Report, GAO-10-1020R

**Enclosure**

Department of Defense (DoD) Comments on Draft GAO-10-1020R, Joint Strike Fighter: Assessment of DoD's Funding Projection for the F136 Alternate Engine, dated September 15, 2010 (GAO Code 120927).

**GAO Finding:** (Page 2) "DoD'S Alternate Engine Cost Projection is Not a Detailed, Comprehensive Estimate"

**DoD Comment:** The DoD cost projection was prepared to inform the Department's senior leadership on resources necessary to make the alternate engine competitive if a decision were made to fully fund the F136 alternate engine program to support a competitive acquisition strategy. This spans 2011 to 2016. The two largest components of this cost estimate are the costs to complete development of the F136 engine, and costs to initiate non-competitive procurement of engines during a period of "directed buys." The cost estimates for these two activities are derived from previously prepared, detailed, and careful analyses of costs based on empirical data from these and prior tactical fighter propulsion programs. The strength and validity of these cost estimates is proven by the fact that subsequent actual cost return information from the F135 and F136 engine programs is consistent with the DoD forecasts. As a result, we continue to believe that the Department's \$2.9 billion cost estimate to complete F136 development activities and prepare the vendor for competition is built upon a solid foundation.

**GAO Finding:** (Page 4) "Two Key Assumptions Significantly Impact Projected Funding Needs"

**DoD Comment:** The GAO points out two scenarios in which less than \$2.9 billion would be required to fund the alternate engine program throughout the FYDP: 1) if the period of directed buys is less than the four years assumed by the Department; and 2) if the incentives introduced through competition encourage the contractors to employ their own corporate resources to fund product improvements, obviating the need for a separate government-funded component improvement program (CIP) during the competition.

- *Period of Directed Buys:* The Department's cost estimate assumes four years of directed buys are necessary, consistent with the analytic assumptions used in the Department's 2007 Congressionally-mandated study on the alternate engine program. More importantly, a period of four years offers the appropriate balance of risk in planning for the conduct of concurrent engine and aircraft development, test, and production activities. We note that GAO itself has consistently expressed concern about the potential for introduction of excessive concurrency into the Joint Strike Fighter program.<sup>1</sup>

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<sup>1</sup> For example, Mr Sullivan, in GAO-10-478T (Testimony Before the Subcommittees on Air and Land Forces and Seapower and Expeditionary Forces, Committee on Armed Services, House of Representatives), stated the following regarding the JSF program: "A recurring theme in our work has been concern about what we believe is undue concurrency of development, test, and production activities and the heightened risks it poses to achieving good cost, schedule, and performance outcomes."

A period of four years of directed buys would enable the alternate engine contractor to complete engine qualification activities; establish a production line; and achieve a competitive footing to begin production. The assumption that these activities can be successfully accomplished in less than four years would impose additional risks on the JSF propulsion and aircraft programs. As of April 2010, the alternate engine had completed only 700 hours of a planned 10,000-hour test program. The bulk of the planned testing for the alternative engine is planned to occur in FY 2012 thru FY 2014. Also, no flight testing of the F136 engine has occurred to date. Qualification activities for the JSF aircraft program are now planned to extend into FY 2015. With this JSF program schedule, the Department's assumption of four years of directed buys for the JSF engine competition would incorporate two years of concurrency with development and qualification activities for the second engine (i.e., FY 2013-14), and would allow the two years following (i.e., FY 2015-16) for the second engine vendor to mature production processes to enable engine price offers that are comparable to those of the lead engine vendor.

- Government Funded Component Improvement Program: As the GAO points out, the Department's estimate includes \$345 million for a discrete Component Improvement Program (CIP) for the F136 engine. DoD did not assume that competition itself would incentivize the contractor to bear the full burden of the costs of a CIP program, while simultaneously offering dramatic reductions in engine prices during procurement competitions. The Department's analysis of the alternative engine accounted for the benefits of competition through projected price reductions beginning in FY 2017, together with the assumption that some level of government funding is required to maintain a standard CIP for the alternate engine during the competition. In reality, the benefits of competition would be driven by the incentives the government chose to emphasize during annual competitions, whether focus on reduced acquisition prices, design and reliability improvements, or some combination of the two. Using the terms of competition to drive design improvements would tend to reduce the direct benefits realized from price reductions offered during a competitive procurement phase.

**GAO Finding:** (Page 4) "Based on the GAO Cost Estimating and Assessment Guide, providing decision makers with a range of costs around a point estimate would be more useful, particularly when information on cost, schedule and technical risks is limited."

**DoD Comment:** The purpose of the Department's \$2.9 billion cost projection was to inform decision-making on resourcing of the alternative engine program in the President's Budget request and the Future Years Defense Program (FYDP). A point estimate is most appropriate for this decision since the FYDP, as well as the President's budget request, requires a single estimate of required resources for a given program in each specific fiscal year.

**General DoD Comments:** Based on the rigor in methods used in building estimates, the collection and use of historical cost information from the F135, F136, and other tactical aircraft propulsion programs, and the review of applied assumptions, we project that it is about equally likely that our \$2.9 billion cost projection to prepare the F136 for competition would prove too low or too high. The GAO analysis is focused solely on describing factors that would drive funding requirements for the alternative engine to be lower than our \$2.9 billion figure (i.e., directed buys and discrete funding of CIP). Also, GAO's assessment (i.e., page 4) identifies

other factors that may generate lower prices, specifically a different design that results in a different cost improvement curve, or the ability of the F136 engine to take advantage of lessons-learned from the F135 experience. The benefits of these two items are ambiguous: it may be that the design of the F136 results in a higher, rather than a lower initial price and production cost improvement curve. Also, issues associated with sharing contractor proprietary information during competition could reduce the benefits of lessons-learned that could be shared between two engine providers.

GAO's assessment is generally silent with respect to a number of plausible scenarios in which the estimate of the cost of preparing the alternate F136 engine for competition would be higher than the \$2.9 billion figure. Instead, the focus of the report is on scenarios in which costs could be reduced. This may mislead readers to assume that \$2.9 billion is at the high end of the range of possible outcomes for the F136 program. This is not the case.

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