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CRS Report for Congress

Proposed Termination of Joint Strike Fighter (JSF) F136 Alternate Engine

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Proposed Termination of Joint Strike Fighter (JSF) F136 Alternate Engine

Summary

The Department of Defense's (DOD) FY2009 budget proposes to cancel the F136 alternate engine for the F-35 Joint Strike Fighter (JSF), a program that was initiated by Congress in the FY1996 Defense Authorization Act, and which has received consistent congressional support since its inception. DOD also proposed terminating the F136 in both its FY2007 and FY2008 budgets; however, Congress rejected both of these proposals.

In FY1996, defense authorization conferees (H.Rept. 104-450, Sec. 213) expressed their concern over a lack of engine competition in the JSF program and directed DOD to ensure that the program "provides for adequate engine competition." (p.706)[1] In FY1998, authorization conferees (H.Rept. 105-340, Sec. 213) directed DOD to certify that "the Joint Strike Fighter Program contains sufficient funding to carry out an alternate engine development program that includes flight qualification of an alternate engine in a joint strike fighter airframe." (p.33) Since its inception in 1997, both DOD and Congress have funded $2.1 billion for the Joint Strike Fighter alternate engine program. The alternate engine program is expected to need an additional $1.3 billion through 2013 to complete the development of the F136 engine.

Some have criticized DOD and the Air Force for being short-sighted with its proposal to terminate the F136 alternate engine. Critics of the decision, not to mention OSD and the Air Force itself during testimony before Congress, note that it was driven more by immediate budget pressures on the department rather than long term pros and cons of the F136 engine program. Others applaud this decision, and say that single source engine production contracts have been the norm, not the exception. Long-term engine affordability, they claim, is best achieved by procuring engines through multiyear contracts from a single source.

Cancelling the F-136 engine poses questions on operational risk and potential cost and savings. Additional issues include the potential impact this termination might have on the U.S. defense industrial base, and on U.S. relations with key allied countries. Finally, eliminating competitive market forces for DOD business worth billions of dollars may concern those who wish to change DOD's acquisition system and achieve what they see as higher standards of accountability.

This report will be updated as events warrant.

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[1] At that time, the JSF program was The Joint Advanced Strike Technology Program (called JAST).

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Introduction

The Department of Defense's (DOD's) FY2009 budget proposes for the third year in a row to cancel the F136 alternate engine for the F-35 Joint Strike Fighter (JSF). The F136 engine is built by the GE/Rolls Royce (GE/RR) Fighter Engine Team and is an alternate engine to the Pratt & Whitney (P&W)-built F135. Pratt & Whitney's F135 engine is a derivative of its F119 engine developed for and used on the F-22. GE/RR's F136 is a derivative of its F120 engine initially developed to compete with the F119. The alternate engine program was initiated by Congress in the FY1996 Defense Authorization Act, and has received consistent congressional support since its inception.[2] The reason usually cited for this proposed cancellation is that it would save close to $2 billion over the Future Years Defense Plan (FYDP), yet entail little operational risk.

Some DOD leaders, however, have expressed mixed feelings about the proposal to cancel the F136 and note that near-term budget constraints are driving their actions. On February 16, 2006, then Secretary of Defense Rumsfeld testified that the merits of terminating the F136 were "clearly debatable."[3] On March 1, 2006, Air Force Secretary Michael Wynne testified that he was worried about the "downstream effects" of this decision.[4] Again in 2008, both Secretary Wynne and General Moseley, Air Force Chief of Staff, testified to their personal desire to keep the alternate engine program "alive."[5] While these statements may suggest that there is a lack of consensus within DOD regarding the value of an alternate engine for the F-35, a continual point brought up by DOD and the Air Force is that the F136 does not pass the "business case" for its continuation.

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[2] More information about the F-35 Joint Strike Fighter can be found in CRS Report RL31360, *Joint Strike Fighter (JSF): Potential National Security Questions Pertaining to a Single Production Line* and CRS Report RL30563, *F-35 Joint Strike Fighter (JSF) Program: Background, Status, and Issues.*

[3] Michael Bruno. "House defense appropriators push back on JSF engine." *Aerospace Daily & Defense Report*. February 17, 2006.

[4] CONGRESSIONAL TRANSCRIPTS. *Reuters*. Congressional Hearings. March 1, 2006. House Armed Services Committee Holds Hearing on FY2007 Budget: Air Force

[5] CONGRESSIONAL TRANSCRIPTS. *Reuters*. Congressional Hearings. March 5, 2008. Senate Armed Services Committee Holds Hearing on FY2009 Budget: Air Force

However in 2007, after overruling DOD's second successive attempt to terminate funding for the second engine, Congress stipulated in the 2008 National Defense Authorization Act (NDAA) (P.L. 110-181, Sec 213))[6]:

> The Secretary of Defense was to "ensure the obligation and expenditure in each such fiscal year of sufficient annual amounts for the continued development and procurement of two options for the propulsion system for the Joint Strike Fighter."

Congress has already taken exception to the third attempt by DOD to terminate funding for the alternate engine program. During recent testimony, Representative Neil Abercrombie expressed frustration with DOD for not following congressional direction in the 2008 NDAA to ensure sufficient funding for a second engine.[7] Representative Abercrombie concluded the hearing's discussion on the alternate engine by telling Mr. John Young, Undersecretary for Acquisition, Technology, and Logistics, to "go back and add [the funding for the alternate engine] in."[8]

As of today, both the House Armed Serviced Committee (HASC) and the Senate Armed Services Committee (SASC) have included funding for the alternate engine program in their committee reports. The SASC recommended an increase of $430 million for the F136, while the HASC recommended $526 million.[9] In addition, the SASC recommended an additional $35 million for F135 engine technology development.

Background

In FY1996, defense authorization conferees (H.Rept. 104-450, Sec. 213) expressed their concern over a lack of engine competition in the JSF program and directed DOD to ensure that the program "provides for adequate engine competition." (p.706)[10] In FY1998, authorization conferees (H.Rept. 105-340, Sec. 213) directed DOD to certify that "the Joint Strike Fighter Program contains sufficient funding to carry out an alternate engine development program that includes flight qualification of an alternate engine in a joint strike fighter airframe." (p.33)

Congress's interest in establishing and funding an alternate engine to the JSF's primary engine — the Pratt & Whitney F135 — may have been informed by what has

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[6] See Conference Report to accompany H.R. 1585.

[7] CONGRESSIONAL TRANSCRIPTS. *Reuters*. Congressional Hearings. March 11, 2008. House Armed Services Subcommittee on Air and Land Forces and the Subcommittee on Sea and Expeditionary Forces Holds Joint Hearing on the Department of the Navy and Air Force Tactical Aviation Programs.

[8] Ibid.

[9] See Conference Report to accompany S. 3001 (p. 222) and Conference Report to accompany HR. 5658 (p. 228).

[10] At that time, the JSF program was The Joint Advanced Strike Technology Program (called JAST).

become known as "The Great Engine War" that ran from 1984 to 1994. The Great Engine War describes the competition between Pratt & Whitney (P&W) and General Electric (GE) to produce engines (the F100 and F110 respectively) to power the Air Force's F-16 *Falcon* fighter aircraft.[11] This competition was held annually between 1984 and 1994 to produce and maintain these engines for the Air Force. After 1994, P&W and GE continued to compete for engine business among foreign air forces that operated the F-16 and F-15. At the time, this acquisition strategy was unprecedented and controversial. Many extolled the advantages of competition and the benefits it conferred to DOD and the taxpayer. Others, however, believed that the engine competition "unjustifiably jeopardized combat effectiveness and pilot survivability."[12]

The Great Engine War's roots extend well before 1984. In the development of the F100 engine for the F-15 in the 1970s, historians note Air Force frustrations with Pratt & Whitney's management along with concerns about a sole-source engine powering their fighter fleet as the impetus for an alternate engine. While the F100 was the most advanced engine ever developed at that time, its rushed development to meet F-15 initial fielding deadline prevented problems from being properly addressed. In addition, one report notes that "[t]he F100 engine was so powerful and the F-15 so maneuverable that pilots began pushing the aircraft to the edge of the performance envelope in ways that stressed the engine far more than had been anticipated."[13] Mounting frustrations over Pratt & Whitney's reluctance to fully address the F100's shortcomings without additional funding resulted in the Air Force, Navy, and Congress working in concert to fund work on an alternate engine.[14] After a number of contentious hearings in 1979, Congress provided funding through the Engine Model Derivative Program (EMDP), a congressionally directed program of the 1960s, for GE to develop its F101 alternate engine (to become the F110). Ultimately, DOD spent over $376 million to develop the F110 to compete with the F100, and $600 million to improve the F100's durability and reliability to make it a stronger competitor. Proponents believe that the annual competition during the Great Engine War produced better engines, on better terms, for less money than would purchasing from a single company facing no competition. Recently, contrary opinions have emerged, and Pratt and Whitney notes that "[t]here is no evidence that the F-16 engine competition saved money."[15] However, a preponderance of the studies on the Great Engine War note that contractor responsiveness was the driving force behind the competition, and not dollar savings.

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[11] While the competition was the result of the Air Force's concerns with the reliability of the F100 in the new single-engine F-16, GE's F110 engine was also eventually used in the dual-engine F-15.

[12] Robert W. Drewes. *The Air Force and the Great Engine War*, National Defense University Press, Washington DC, 1987.

[13] Karl G. Amick. *The Next Great Engine War: Analysis and Recommendations for Managing the Joint Strike Fighter Engine Competition*, Naval Postgraduate School, Monterey, CA. 2005, p. 8.

[14] Ibid, pp. 92-98.

[15] "Joint Strike Fighter - Engine Development," (JSF Talk-3) *Talking Points*. Pratt & Whitney. February 23, 2006.

Some have criticized DOD as being "penny wise and pound foolish" in its proposal to terminate the F136. Critics argue that this decision appears driven more by immediate budget pressures on the department rather than long term pros and cons of the F136 program. For example, Secretary of the Air Force Michael Wynne reportedly said that the idea of cancelling the F136 "came up during the QDR, in the course of attempts to identify ways to save costs at the Pentagon."[16] Others applaud this decision, and say that single source engine production contracts are the norm, not the exception. Long-term engine affordability, they claim, is best achieved by procuring engines through multiyear contracts from a single source.

Congressional response in 2006 and early 2007 to the F136 termination proposal was both positive and negative. Those in favor of continued F136 development prevailed, however. Both authorization and appropriations conferees included funds in FY2007 for continued F136 development, strong language supporting the program, and directed DOD and other agencies to conduct independent analyses of potential F136 cost savings.[17] By March 2007 OSD's Cost Analysis Improvement Group, the Government Accountability Office, and the Institute for Defense Analyses had all completed their reports on the merits of the alternate engine program (results summarized in the next section).

It appears that the Administration's decision in FY2009 budget to terminate F136 is again influenced more by near-term budgetary pressures than by the potential gains in the future. The alternate engine program appears to be affected in budget considerations by the fact that its benefits won't be realized for a decade, while its costs are noteworthy, and immediate.

Congressionally Mandated Studies

The 2007 National Defense Authorization Act (P.L. 109-364; 120 Stat 2117 [Sec. 211]) directed OSD and the Comptroller General to conduct three independent cost-benefit analyses on having an alternate engine for the F-35 Joint Strike Fighter. Section 211 also directed OSD to continue funding the development and procurement of an alternate engine until the three directed reports were submitted and the congressional defense committees notified of any programmatic change. Each of these reports was conducted independently using the same data provided by the contractors and by the Joint Strike Fighter Program Office.

OSD Cost Analysis Improvement Group

OSD Cost Analysis Improvement Group (CAIG) concluded its analysis in March 2007.[18] The CAIG compared the results of the engines developed during the

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[16] Richard Mullen. "Cutting JSF Engine Was Navy Idea: Wynne." *Defense Today Instant Update*. March 2, 2006.

[17] See, H.R. 5631 (109-676), p. 228. H.R. 5122 (109-702) Sec. 211 (p.36).

[18] The Cost Analysis Improvement Group (CAIG) is under the administrative control of (continued...)

"Great Engine Wars," the engine competition for the F/A-18 aircraft,[19] and the sole-source Pratt and Whitney F-119 engine for the F-22. Given their analysis of past cost performance stemming from competition, the CAIG report noted their baseline "assumptions [were] generally favorable to dual source case."[20] The CAIG assumed that the follower, in this case the GE-Rolls Royce Fighter Engine Team (F136), would meet leader (Pratt & Whitney F135) pricing in 2014 (first year of competition). The CAIG also assumed that there would be both an immediate 5% price decrease and a 5% increase in the rate for cost improvement (what the CAIG calls "learning curve rotation"[21]) over the lifetime of the program.

Overall, the CAIG estimated that the competition would require a 21.1% reduction in costs (in constant FY2002 dollars) over the lifetime of the program in order to break even. The break-even cost reduction requirement climbs to 25.6% when converted to net present value.[22] The CAIG estimated that DOD would be unable to recoup its initial investment in the alternate engine development program through procurement savings alone. The CAIG report noted DOD would have to effectively compete Operations and Support (i.e., maintenance) contracts and attain a 25.6% savings, which the report seems skeptical of attaining, in order to eventually reach a "break even" point by 2040.[23]

While the CAIG report highlights from a financial standpoint that the alternate engine program might eventually break even over time, the CAIG goes on to note a number of non-monetary benefits that could be gained through having an alternate engine program for the F-35. One of the most notable appears to be the issue of growth potential in the Joint Strike Fighter engine. As shown in the figure below, the

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[18] (...continued)
OSD's Director of Program Analysis and Evaluation and is tasked with providing independent cost assessments of major defense acquisition programs. The CAIG also serves as the principle advisor to the Milestone Decision Authority on program life-cycle costs. See DoDD 5000.04 for additional information on the CAIG and its independent analysis role.

[19] Unlike the F100/F110 competition, the competition for the F/A-18 (the F404 engine) differs from the Great Engine War in that both GE and P&W competed only in cost since they were both building identical GE-designed F404 engines. Analysts note that the F404 competition removed a key component, engine design, since both companies built their engines to the same blueprints. Therefore, analysts note that the F404 competition did not achieve the same results as the previous F100/F110 competition for independently-designed engines.

[20] OSD Cost Analysis Improvement Group Report (v6), "F-35/JSF Alternate Engine Acquisition and Independent Cost Analyses," March 15, 2007, Slide 31.

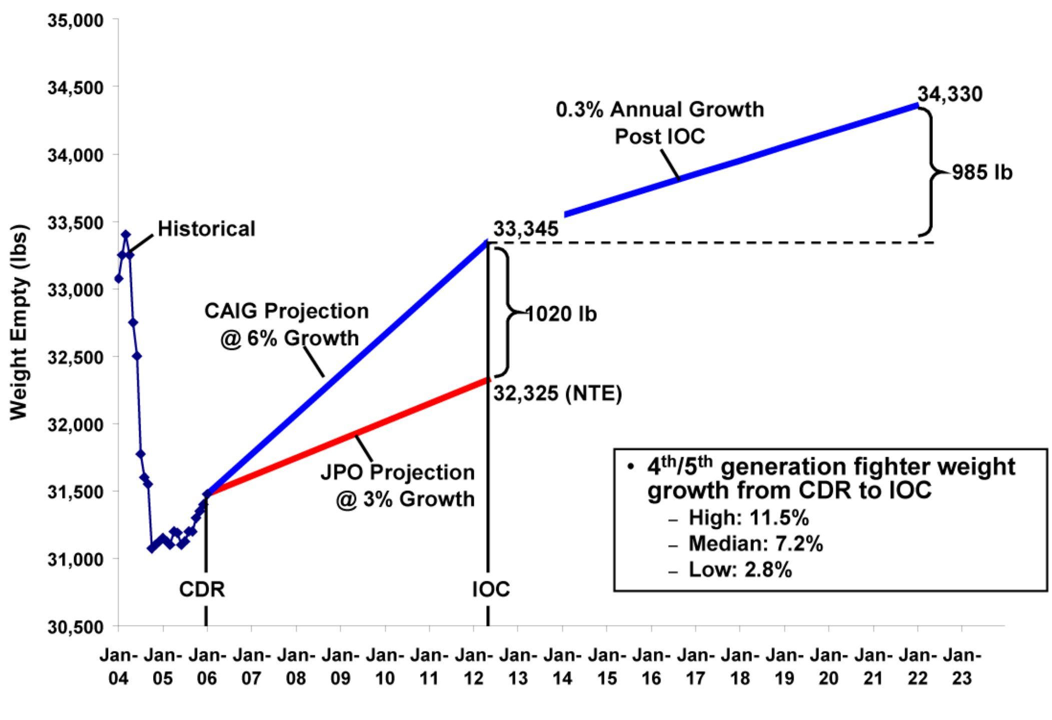
[21] In discussion with the CAIG, learning curve rotation was defined as the effect competition has on the learning curve. In this case, competition would result in both competitors streamlining their processes in order to compete more effectively (maximize efficiency), hence lower cost to the Air Force.

[22] Net present value is the discounted present value of the return on investment when taking risk and other potential investment opportunities into consideration. It is considered the standard method for financial appraisal of long-term projects.

[23] OSD CAIG Report, Slide 37.

CAIG estimates that the average aircraft weight growth of a 4th/5th generation fighter from Critical Design Review to Initial Operational Capability is 7.2% with a 0.3% weight growth thereafter.[24] Basically, the initial planned empty weight of an aircraft could grow, over time, beyond the thrust margins of safety provided by the engine. Eventually, the engine would have to be upgraded for additional thrust to overcome the additional aircraft weight. The CAIG report notes that Pratt & Whitney's F135 engine is already close to exceeding the designed engine temperature specifications. Therefore, the F135 engine would require additional modifications beyond that of the GE-Rolls Royce F136 engine to allow for thrust growth.[25]

Figure 1. F-35 STOVL Variant Weight Growth Projection



Source: OSD CAIG F-35/JSF Alternate Engine Acquisition and Independent Cost Analyses Report, March 15, 2007.

Institute for Defense Analyses

The Institute for Defense Analyses (IDA) was selected by OSD as the Federally Funded Research and Development Center (FFRDC) to perform the independent cost

[24] The CAIG's analysis of expected future weight growth is not in line with the Joint Program Office's estimate that weight will unchanged after Initial Operational Capability (IOC). The CAIG slide shows historical data showing expected weight growth of 2.8% to 11.5% following IOC from other 4th and 5th generation fighter aircraft. Additionally, the CAIG's estimated pre-IOC weight growth of 6% is in stark contrast to the JPO's estimate of 3%.

[25] Ibid. Slides 25 and 26. Note: Since the F136 is earlier in its development cycle, analysts comment that its design is not as set as the F135 and could better incorporate engine growth requirements without major modifications.

analysis of the F136 engine program. IDA provided its cost analysis in March 2007 and completed its final report in July 2007. IDA, as with the CAIG analysis, examined the Great Engine Wars of the 1980s along with the F404 engine competition for the F/A-18. Its analysis showed an estimated gross savings due to competition ranging from 11% to 18%.[26] When examining past studies of various procurement competitions, IDA determined that these studies showed an average (un-weighted) savings of 14.6%.[27]

Examining the break-even point for the case of the F136, IDA determined the overall increase in cost of having an alternate engine program (both direct and indirect costs) to be $8.8 billion (FY2006 dollars).[28] As was the case with the CAIG's findings, IDA concluded that it would not be feasible to recoup DOD's investment in an alternate engine if procurement costs alone were competed. IDA determined for the alternate engine program to break even, on a net present value basis, the savings required would fall from an "unrealistic" 40% to 18% (net present value) when Operations and Support (O&S) contracts are also competed.[29] This is somewhat in line with the CAIG and shows a potential for DOD to recoup its investment throughout the life of the alternate engine program. However, IDA noted that DOD "has not typically linked procurement and O&S costs in a single competition," and therefore had limited historical data in which to estimate plausible O&S savings (raising doubts as to how successful this will be in the future).[30]

IDA, like the CAIG, also noted a number of other benefits stemming from competition. Improved fleet readiness, reduced risk, and industrial base sustainment are common benefits cited by both reports. However, IDA notes that contractor responsiveness was "the primary motivation for the Great Engine War."[31] IDA goes on to note that by 2035 that the F-35 would comprise 95% of the U.S.'s fighter attack force. Thus, with an alternate engine program, any future groundings will only affect a portion of the fleet. In addition, enhanced industry responsiveness to engine upgrades and fixes resulting from competitive forces could potentially have a profound effect on overall fleet readiness.

[26] Institute for Defense Analyses Report: "Joint Strike Fighter (JSF) Engine Cost Analysis: Summary of Results (Revised)," March 2007, Pg S-3. NOTE: IDA determined a 11% savings from competition over the upgraded F100-220 P&W engine and an 18% savings from competition between the original P&W F100 and the GE F110 (Pg 23).

[27] Ibid. Pg 24. However, IDA noted "significant inconsistencies" with studies of past competitions which need to be taken into consideration when evaluating potential savings.

[28] Ibid., p. 20.

[29] Ibid., p. S-3.

[30] Ibid., p. S-3.

[31] Ibid., p. 44.

Government Accountability Office

The Government Accountability Office (GAO) report noted that savings of 10.3% to 12.3% would be required for the alternate engine program to break even.[32] GAO goes on to note that analysis of past engine competitions have shown financial savings of up to 20%.[33] Therefore, GAO concludes that it is reasonable to assume that savings generated from competing the engine would recoup DOD's investment. In addition, during testimony, Michael Sullivan, Director of GAO's Acquisition and Sourcing Management, noted that he believed the alternate engine program would reach its break-even point by the late 2020s.[34]

Similarities and Differences Between the Studies

What appears to be the key difference between the three studies is the break-even point analysis for the alternate engine program. The GAO noted in its report a maximum savings requirement of 12.3% in order to recoup DOD's "future" investments in the late 2020s. OSD's CAIG and IDA require savings of 25.6% and 18% respectfully, in net present value, to break even in the 2040 time frame. Michael Sullivan, from GAO, testified that he speculated the other two studies may have included a portion of costs sunk into the alternate engine program.[35] However, in response, James Woolsey, from IDA, noted that IDA did not include sunk costs, and also commented that he thought the major difference between GAO and the other studies had to do with costs associated with operations and support (O&S).[36] He contended that IDA included sustainment engineering costs, costs to improve the engine, and additional costs tied to two supply chains that might not have been included in the GAO's analysis.

GAO analysts, however, noted that under a competitive environment, the need for an F-35 engine Component Improvement Program (CIP) would be reduced, and therefore potential funding required for CIP was not included in their analysis.[37] Engine CIP funding is normally designed to be "reactive and proactive throughout an engine's life cycle to resolve newly identified problems, and to find ways to reduce costs of aircraft and engine ownership."[38] Basically, CIP is designed to fund

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[32] *Analysis of Costs for the Joint Strike Fighter Engine Program*, GAO-07-656T, March 22, 2007, p. 1.

[33] Ibid., p. 2.

[34] CONGRESSIONAL TRANSCRIPTS. *Reuters*. Congressional Hearings. March 2, 2007. House Armed Services Subcommittee on Air and Land Forces and the Subcommittee on Seapower and Expeditionary Forces Holds Joint Hearing on the Department of Defense Aircraft Programs.

[35] Ibid.

[36] Ibid.

[37] Telephonic conversation with Bruce Fairbairn, GAO Assistant Director Acquisition and Sourcing Management, April 23, 2008.

[38] Chris J. Borer. *An Analysis Of The Aircraft Engine Component Improvement Program*

(continued...)

problem solving and problem avoidance along with product improvement and maturation.[39] However, CIP is not designed to fund engine performance improvements beyond the initial design, only to reduce life cycle costs of operating the engine. It was GAO's opinion that competition would result in industry funding its own product improvements in order to win greater market share. Therefore, the need for CIP funding would be reduced from what is normally budgeted for sustainment engineering. IDA, in its report, fully examined the requirement for CIP and noted there was still a requirement for CIP with the F100 and F110 engine, both engines that were part of the Great Engine War.[40]

While all three independent reports came to different conclusions as to the break-even point, they all agreed there are a number of non-financial benefits that would be derived from an engine competition. Each of the studies notes expected improvements in fleet readiness, contractor responsiveness, sustainment of industrial base, and stronger international relations by having the alternate engine for the F-35. The GAO report notes that DOD's program management advisory group in 1998, and again in 2002, recommended continuing the alternate engine program due to these non-financial benefits in spite of only finding marginal financial benefits.

Issues

As DOD has noted, cancelling the F136 poses questions on operational risk and potential cost and savings. Additional issues include the potential impact this termination could have on the U.S. defense industrial base, and on U.S. relations with key allied countries. Finally, eliminating competitive market forces for DOD business worth billions of dollars may concern those who wish to change DOD's acquisition system to achieve what they see as higher standards of accountability.

Relations with Key Allies

The F-35, unlike the F-22, has been designed from the outset for export. Allied participation in JSF program development, and sales stemming from program participation, have been actively pursued as a way to defray some of the cost of developing and producing the aircraft. Congress insisted from the outset that the JAST program include ongoing efforts by the Defense Advanced Research Projects Agency (DARPA) to develop more advanced short takeoff and vertical landing (STOVL) aircraft, opening the way for British participation.

Eight countries — Australia, Canada, Denmark, Italy, Netherlands, Norway, Turkey, United Kingdom — have pledged about $4.5 billion to join in JSF development as partners for the initial System Development and Demonstration

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[38] (...continued)
(CIP): A Life cycle Cost Approach, Naval Postgraduate School. December 1990. Pg. 5.

[39] Ibid.

[40] Telephonic conversation with Mr. James Woolsey, IDA's project leader for their analysis on the F136 alternate engine report, April 25, 2008.

(SDD) phase. In addition, all eight partner nations have signed the subsequent Production, Sustainment, and Follow-on Development (PSFD) Memorandum of Understanding stating their intentions to actually purchase the aircraft. Israel and Singapore have both signed letters of intent to become Security Cooperation Participation (SCP) nations in the JSF program and to contribute $50 million. Spain, Greece, Japan, and South Korea have also been expressing interest in purchasing the F-35, though none of those nations are current participants in the program. Jon Schreiber, Joint Strike Fighter Director of International Programs, recently noted that international sales of F-35s could exceed 2,600.[41] The Teal Group estimates the export market for the F-35 to be between 1,700 and 2,500 aircraft.[42]

The United Kingdom is the biggest participant and the only Level 1 partner nation in the program.[43] On December 20, 1995, the U.S. and British governments signed a memorandum of understanding (MOU) on British participation in the JSF program as a collaborative partner in the definition of requirements and aircraft design. This MOU committed the British government to contribute $200 million towards the cost of the 1997-2001 concept demonstration phase.[44] In addition, on January 17, 2001, the United Kingdom signed an MOU with the United States committing the British government to spend $2 billion on JSF SDD. British firms, such as Rolls-Royce and BAE, have benefitted from the US/UK partnership in JSF. BAE is a major partner to Lockheed Martin and is providing the aft fuselage, empennage, and Electronic Warfare Suite for the F-35. Also, not only is Rolls-Royce partnered with GE on the F136 engine, Rolls-Royce is under contract with Pratt & Whitney to produce the LiftSystem components of the F135 STOVL Propulsion System. The 2001 contract with Pratt & Whitney to cover the design and development work of the STOVL elements during SDD is worth $1 billion to Rolls-Royce over 10 years.[45] Regardless of which engine is placed in the F-35, Rolls-Royce LiftSystem will provide the vertical lift of all STOVL aircraft.

Friction has existed between DOD and many foreign partners in the JSF program. Denmark, Italy, the Netherlands, Norway, and Turkey have expressed dissatisfaction with the quality and quantity of the work their companies have been awarded on the F-35.[46] These countries have threatened to reduce their participation

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[41] Carlos Munoz. "JSF Program Leaders Expect Surge in International Participation," *Inside The Navy*, August 27, 2007. Note: Mr. Schreiber noted that overall F-35 production could exceed 5,000. Noting the expected US procurement of around 2,400 aircraft, the remaining 2,600 would be international sales.

[42] Richard Aboulafia. Lockheed Martin F-35 Joint Strike Fighter Program Briefing, The Teal Group, March 2008.

[43] Level 1 Partner status requires approximately 10% contribution to aircraft development and allows for fully integrated office staff and a national deputy at director level. Only one Level 1 partner nation allowed. See [http://www.teamjsf.com] for more information.

[44] U.S., U.K. Sign JAST Agreement. *Aerospace Daily*, December 21, 1995: 451.

[45] "Rolls-Royce Finishes First JSF Propulsion System Flight Hardware," Rolls-Royce Media Room at [http://www.rolls-royce.com/media/showPR.jsp?PR_ID=40243].

[46] "Norway Signs Industrial Partnership with Eurofighter Consortium," *Defense Daily*,
(continued...)

in the program, or purchase other European fighters instead of the F-35. The governments of Italy and the United Kingdom have both lobbied for F-35 assembly facilities to be established in their countries. Current international content in the initial F-35 aircraft is approximately 20%.[47] Lockheed Martin expects international content to potentially expand to about 30% as the program transitions to full-rate production and the supply base potentially diversifies.[48]

Technology transfer has also been a contentious issue, with foreign partners arguing that the United States is too cautious in sharing the JSF's technical capabilities. Congress, in the John Warner National Defense Authorization Act for Fiscal Year 2007, sensing United Kingdom frustrations with technology-sharing, advised the Secretary of Defense to share technology consistent with the national security interests of both nations.[49] Program officials note that they are working with partner nations to improve their ability to effectively compete for JSF work and are working with DOD expedite technology-transfer issues.[50]

Canceling the F136 would likely mean a considerable loss of revenue for GE's UK-based partner, Rolls Royce. Although Rolls Royce has established business relations with Pratt & Whitney, this business appears to be far short of the 40% partnership Rolls enjoys with GE. In addition, Rolls Royce will be opening up a new plant in Virginia in 2009 that is anticipated to make parts for the F136 engine.[51]

It is unclear how, or to what extent, terminating the F136 would harm the JSF program's international participation. Early allied response has not been positive. The United Kingdom's top defense procurement official reportedly stated that his country would cease participation in the JSF program if the F136 engine were cancelled and technology transfer issues were not resolved to its satisfaction.[52] In addition, Dr. Liam Fox, a Conservative member of the House of Commons, stated back in 2006 that the Pentagon's decision to drop the F136 would also "invariably effect future procurement decisions, with seriously negative consequences that may

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[46] (...continued)
January 29, 2003. Joris Janssen Lok, "Frustration Mounts Among JSF Partners," Jane's Defense Weekly. March 24, 2004. Thomas Dodd, "Danish Companies Consider Quitting JSF Programme," Jane's Defence Weekly, January 9, 2004. Tom Kingston, "Unsatisfied Italy May Cut JSF Participation," Defense News, May 10,2004. Lale Sariibrahimoglu, "Turkey may withdraw from JSF program," Jane's Defence Weekly, November 10, 2004.

[47] "F-35 International Program Content," JSF Joint Program Office paper, March 4, 2008.

[48] Ibid.

[49] P.L 109-364; 102 Stat 2134; October 17, 2006.

[50] Eric Tegler, "International Instrument: Building the F-35 In Partnership," *F-35 Lightning II Commemorating First Flight*, p. 81.

[51] John R. Blackwell, "New Plant To Add 170 Jobs," *Richmond Times-Dispatch*, November 21, 2007.

[52] Megan Scully. "British Demand Better Access To Fighter." *NATIONAL JOURNAL'S CONGRESS DAILY AM*. March 15, 2006. George Cahlink. "U.K. Procurement Chief Warns Backup Engine Dispute Threatens JSF Deal." *Defense Daily* March 15, 2006.

not be fully appreciated on this side of the Atlantic."[53] Dr. Fox goes on to say that "without doubt, cancellation of the program would play into the hands of those in Europe who are even now all too willing to suggest the U.S. cannot be relied on and that Britain should look instead to France and European institutions on defense."[54]

However, other European countries, such as the Netherlands, have firms making inroads into both the F135 and F136 programs. The Dutch currently have 74 companies and research labs involved in the JSF program.[55] As European companies secure more and more contracts, the debate within each of the partner nations over the need for the second engine might become more complicated.

Operational Risk

DOD officials argue that terminating the F136 poses little operational risk. The decision to pursue an alternate engine for F-14s, F-15s, and F-16s, they say, came at a time when the Services were dissatisfied with the performance of existing engines (TF30 and F100). During the "Great Engine War," DOD was more motivated to improve engine performance, reliability, and to reduce operational risk than by potential cost savings. DOD argues that these same conditions do not exist today.

In a briefing provided to Congress in 2006, the DOD Office of Program Analysis and Evaluation (PA&E) stated the F135 engine produced by Pratt & Whitney (P&W) for the F-35 was performing well.[56] Further, PA&E stated that the F119 engine that P&W produced for the F-22A *Raptor*, which served as the basis of the F135, is also performing well. PA&E notes that the F119 has performed well after roughly 18,000 flight hours and will achieve 100,000 flight hours by 2009. This briefing also notes that the F-22 *Raptor* and the F/A-18E/F *Super Hornet* rely on a sole source engine supplier (the P&W F119 and GE F414 respectively), implying that the F-35 can likewise rely on a single engine manufacturer. However, by the time the decision was made to divide engine production contracts between GE and P&W in 1984, the P&W F100 engine had accumulated 2,000,000 hours of operational service. By comparison, the 18,000 hours of testing might be considered a modest foundation to make projections of the F119's future performance.

DOD also argues that industry advances in engine design tools such as computational fluid design for airflow prediction, and advanced software for prognostic health monitoring, further reduce the risk of powering the F-35 with a single type of engine.[57] Presumably, using these tools will result in engines that are capable of self-diagnosis and notification to the pilot of impending failure vice

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[53] Rodney L. Pringle, "JSF Engine Rumblings," *Military Aerospace Technology*, October 8, 2006.

[54] Ibid.

[55] Joris Janssen Lok. "Double Dutch; Pratt, Rolls Involve More Dutch Partners in F135, F136 Programs," *Aviation Week & Speace Technology*, February 11, 2008.

[56] "JSF Alternate Engine Decision" Briefing. OSD/PA&E. February 27, 2006.

[57] Ibid.

simple notification that a failure has occurred. Advanced warning of impending failures will not only allow the pilot time to land prior to failure, it will allow more efficient and cost-effective maintenance procedures and quicker diagnosis of required repair parts.

Others who support DOD's decision to terminate the F136 argue that an alternate engine will not help mitigate risk. One defense analyst postulates that the alternate engine could actually increase operational risk. This analyst notes that engines undergoing maturation first in a twin-engine aircraft (such as the F-15, F-22, or the F/A-18) prior to use in a single-engine aircraft allow more time for detecting and fixing engine deficiencies.[58] Another analyst, however, notes that the F135 is quite different than the F119 it was derived from.[59] Therefore, while being a derivative of an engine first introduced on the twin engine F-22, it is still expected to undergo developmental growing pains with the F-35. In the same vein, the F136 is three to four years behind the F135 in its development and should undergo its own set of developmental growing pains and potential for cost growth.

Recent events with the F135 engine development have increased attention to the issue of risk. Once on August 30, 2007, and again on February 4, 2008, the F135 engine experienced testing failures while on the test stand. The JSF Joint Program Office noted the engine failures in both cases were due to "high-cycle fatigue" resulting in the failure of a third-stage turbine blade.[60] William Balderson, from the Department of the Navy, noted during congressional testimony that the second engine failure was as a result of ongoing testing to determine the causes of the first failure on August 30.[61] Mr. Balderson goes on to note that Pratt & Whitney appears confident that it understands the root causes of the malfunctions and that a design fix is in the works and will be implemented once testing is complete.[62] Program and Service officials note that these engine malfunctions have pushed back the expected first flight of the F-35B aircraft a month or two.

Those supporting an alternate engine point to the potential risk of a future fleet-wide grounding and note that the F-35 will make up a preponderance of the Air Force's fighter fleet. Currently, the Air Force has 183 F-22s with a potential for maybe an additional 24 aircraft. The Air Force is also currently expected to procure 1,763 F-35s over the next 20 plus years. A future fleet-wide grounding of the F-35s, they maintain, would potentially have a debilitating effect on the Air Force. A similar issue, though unrelated to the aircraft engines, was recently experienced when the Air Force twice grounded its fleet of F-15s because of structural problems. The

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[58] Loren Thompson. "Powering JSF — One Engine Is Enough." *Lexington Institute*, January 2008, p. 10.

[59] Telephonic conversation with Richard Aboulafia, Teal Group, on April 22, 2008.

[60] Jason Simpson. "Davis: JSF Program Office Anticipated Early-Stage Engine Problems." *Inside the Air Force*, February 15, 2008.

[61] CONGRESSIONAL TRANSCRIPTS. *Reuters*. Congressional Hearings. April 9, 2008. Senate Committee on Armed Services, Subcommittee on Airland, hearing on Fiscal Year 2009 Budget for Air Force and Navy Aviation programs..

[62] Ibid.

Air Force, however, was able to continue combat operations by leaning on its sizeable fleet of F-16s to take up the slack. The Navy's operational risk should be reduced because its fleet will be more balanced with F/A-18s using the GE-404 (or 414 on the E/F) engines along with their F-35s. While fleet-wide groundings for engine-related malfunctions are rare, they do happen. The Marine Corps, for example, grounded 106 AV-8B Harriers in July 2000 after a faulty engine bearing was cited as the cause of a crash.[63] Since 1997, 66% of the Navy's grounding bulletins were for airframe related issues, whereas 18% were related to engine issues.[64] The Air Force has experienced only two system-wide fleet stand-downs due to engine issues since 1990.[65] Some have responded that the Air Force could find itself in the same grounding predicament with the F-35, based on non-engine issues, regardless of whether there is an alternate engine, because of reduced diversity of its future fighter fleet.

One issue that pertains to operational risk that has not been discussed by DOD is that of reduced fleet readiness due to, for example, a lack of spare parts. Two manufacturers would maintain two supply chains, and perhaps additional suppliers for critical parts. Eliminating one manufacturer could lead to fewer suppliers and potentially leave the remaining supply chain more vulnerable to disruptions caused by labor disagreements, foreign takeovers, or natural disasters. On the other hand, splitting the engine buy will reduce the workload for the supply vendors and increase the level of uncertainty as to the amount of business they will receive. In addition, one defense consulting firm notes that approximately 50% of each engine is procured in a competition environment today, leading one to conclude there are multiple vendors available that could create parts for each of the engines.[66]

During a March 1, 2006, hearing, Secretary of the Air Force Michael Wynne discussed the potential cost and risk of having one engine supplier versus two. Secretary Wynne said that the decision to terminate the F136 was "a very tough call because it involves industrial base and involves long-term reliability statistics and involves economics." In the context of reliability and risk, Secretary Wynne continued with the statement that "I don't like to see our industrial base go to a single supplier."[67]

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[63] Mark Oliva, "Pilots defend Harrier jet." *Stars and Stripes*. (Pacific Edition). January 19, 2003.

[64] "JSF Engine Second Source Executive Summary," Whitney, Bradley, and Brown Consulting; December 2006. Slide 23.

[65] Ibid.

[66] Ibid. Slide 22. Note: See [http://www.wbbinc.com] on Whitney, Bradley, and Brown, their corporate profile and their clients.

[67] CONGRESSIONAL TRANSCRIPTS. *Reuters*. Congressional Hearings. March 1, 2006. House Armed Services Committee Holds Hearing on FY2007 Budget: Air Force

Cost and Savings[68]

Over the past three years, DOD has mainly explained its decision to terminate the F136 on its financial return on its investment. Congressional testimony by OSD/AT&L, the Air Force, and the Navy all note that the business case does not sufficiently support the large, up-front investment in an alternate engine for the F-35. As was previously noted by the three congressionally directed studies and associated testimony back in 2007, while there are a number of non-financial benefits to having an alternate engine, the ability for DOD to recoup its financial investment is a matter of great debate.

It is not surprising that there is a lot of debate on the merits of the F136, especially given the complexity of the issue and the amount of resources required to fund a second engine. There is inevitably a lot of subjectivity when analyzing business cases. In the case of the F136, one will need to assess how likely it is for the program to achieve the estimated savings, the likely number of engines that will be acquired, the potential for the fleet to suffer a debilitating issue related to the engine, how much better the engine designs will improve, and how much more responsive the manufacturers will be under a competitive environment. Not only will one have to assess the ability to achieve financial and non-financial improvements, but one will have to assess the qualitative worth of such savings when compared to the opportunity costs of the investment. Both within DOD and outside, analysts note that the F136 program requires a large up-front investment for benefits that won't be realized for decades. These factors arise in an environment where DOD is facing tough financial choices while on a war-footing and the potential for budget reductions as administrations change.

Two of the key variables in analyzing the business case for the F136 is the development cost of the alternate engine and the number of engines that those costs will be amortized over. Beginning with expected procurement numbers, DOD is currently planning on buying 2,443 F-35s (excluding test articles). The Air Force current engine production profile for the F-35 is for a total of 3,649 engines (3,173 primary engines and 476 spares).[69] This current engine production profile is about 100 engines more than the three congressionally directed studies used for their analysis back in 2007. However, the overall planned DOD procurement of 2,443 operational F-35s is over 500 aircraft less than the 1996 preliminary planning estimate of 2,978 aircraft. It should be emphasized that DOD's planned buy of 2,443 aircraft has remained steady since 2003 when the Department of the Navy, under the Tactical Aircraft Integration Plan, reduced its buy from 1,083 to 680 aircraft.[70]

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[68] To date, approximately $2 billion has been provided to develop the F136 engine. The cost to complete the F136 development phase is estimated at $1.36 billion from FY2009 to FY2013. Source: Provided to CRS by SAF/LLW on April 30, 2008.

[69] SAF/LLW correspondence; April 30, 2008.

[70] The Department of the Navy's buy includes both the Navy's F-35Cs and Marine Corps F-35B's. The Marine Corps have set their requirement for F-35Bs at 420, which would leave 260 F-35Cs for the Navy if the Department of the Navy limits the buy to 680 and fully supports the Marine Corps requirements.

While DOD's procurement numbers have remained steady over the past five years, international orders, as previously mentioned, are expected to exceed the minimum anticipated orders of 646 aircraft and could reach over 2,500 aircraft.[71] In addition, the F-35 is designed to take the place of the F-16, an aircraft with an initial planned run of 1,388 aircraft that eventually exceeded 4,000 built.[72] DOD has been focused on keeping the F-35 program on track and procurement numbers sufficient to prevent undo cost growth. Deputy Secretary of Defense England, in a letter to Congress, noted the Department's desires to procure more F-35s than additional F-22s.[73] Given the disparity between the AF requirement for 381 F-22s and the current program of record of 183 aircraft, there appears to be strong potential for the Air Force requirement of F-35s to grow beyond 1,763 aircraft. If the F-35 program goes beyond current procurement expectations (both for domestic and international orders), the business case for keeping the F136 program alive might be significantly strengthened.

However, current Service and Allies budget pressures along with aircraft cost and development issues may drive lower procurement numbers. One defense analyst notes the Air Force's procurement numbers "are likely to fall to around 1,200-1,400 [aircraft]."[74] Another analytical assessment notes the Air Force's strategy to replace legacy aircraft on a one-for-one basis is excessive, and that one might contemplate 800-1000 F-35As as being sufficient.[75] The Department of the Navy, on the other hand, is facing a tactical aircraft shortfall of around 125 aircraft in 2017. While the Marine Corps appears focused on acquiring the STOVL variant for its modernization efforts, the Navy could potentially acquire additional F/A-18E/Fs to help reduce its fighter shortfall. With the Navy being the only customer for the F-35C, reductions in their numbers could put the viability of the C-variant into question. In addition, there could be fallout over the KC-X competition in which Northrop Grumman/EADS KC-30 tanker won over Boeing's KC-767. Potential fallout could affect the F-35's international orders if the competition results are overturned and European nations backlash against the pricy U.S. fighter. Finally, any program setbacks that result in excessive cost growth beyond what has already been encountered to date could have a profound effect on aircraft orders on both sides of the Atlantic. Therefore, there is a potential that DOD's business case planning factors for the F136 alternate engine might not reach the levels assumed in the current studies — and therefore become a very expensive "nice to have."

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[71] While procurement numbers have remained steady, the length of the acquisition program has been extended due to issues with aircraft weight growth resulting in program delays.

[72] Institute for Defense Analyses Report: "Joint Strike Fighter (JSF) Engine Cost Analysis: Final Report," July 2007, p. 7.

[73] Deputy Secretary of Defense Gordon England letter to Representative Phillip Gingrey in response to Rep. Gingrey's concerns over the F-22; January 14, 2008.

[74] Richard Aboulafia. Lockheed Martin F-35 Joint Strike Fighter Program Briefing, The Teal Group, March 2008.

[75] Steve Kosiak and Barry Watts, *US Fighter Modernization Plans: Near-Term Choices*, Center for Strategic and Budgetary Assessments, 2007.

The other key variable to the business case analysis, the remaining developmental costs of the F136 engine, is estimated to be $1.36 billion from FY2009 to FY2013.[76] In addition, total F136 costs from FY2009 to FY2015 is estimated to be $3.5 billion ($1.36 billion for development, $0.29 billion for Component Improvement Program efforts, $1.71 billion for procurement, and $0.14 billion for initial spares).[77] Noteworthy is the fact that, from FY1995 to FY2008, approximately $2 billion has been provided by DOD to develop the F136 engine — therefore over half of the total development cost of the F136 are sunk costs. While currently not in the DOD budget, $495 million will be required in FY2009 to continue developmental efforts on the F136.[78]

The $290 million required for Component Improvement Program (CIP) efforts might be debatable by some. As previously stated, GAO did not incorporate CIP in its 2007 analysis because of its position that competition would reduce its need.[79] The GAO analysts felt that competition would drive the manufacturers to make the improvements in their engines on their own to help them attain a larger share of the engine contracts. IDA, however, did include CIP after its analysis of the results of the Great Engine War. IDA notes that while CIP funding did not exceed 4% of the estimated life cycle costs in any of their analysis, it is still a cost "that must be approximately doubled to ensure two equally supported engine designs."[80]

Procurement and spares costs will be required, whether there is a single or dual supplier of engines. While the numbers could result in a greater number of spare engines required under a dual supply environment, the overall number should remain close. However, there will be additional costs in maintaining two separate production and supply lines along with the additional management required by the services.

Industrial Base

As noted earlier, DOD officials have expressed concern over the potential impact of this proposed termination on the industrial base. Further, DOD analyses acknowledge that the F136 alternate engine provides "significant" industrial base benefits.[81] Therefore, it is reasonable to assume that the decision to terminate the F136 may have negative consequences on the industrial base. The debate focuses on *how* significant these negative consequences may be.

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[76] SAF/LLW correspondence; April 30, 2008.

[77] Ibid.

[78] Ibid.

[79] Telephonic conversation with Bruce Fairbairn, GAO Assistant Director Acquisition and Sourcing Management, April 23, 2008. Note: While GAO did not include CIP in its analysis, the analyst did not say that the requirement would be completely eliminated, just reduced.

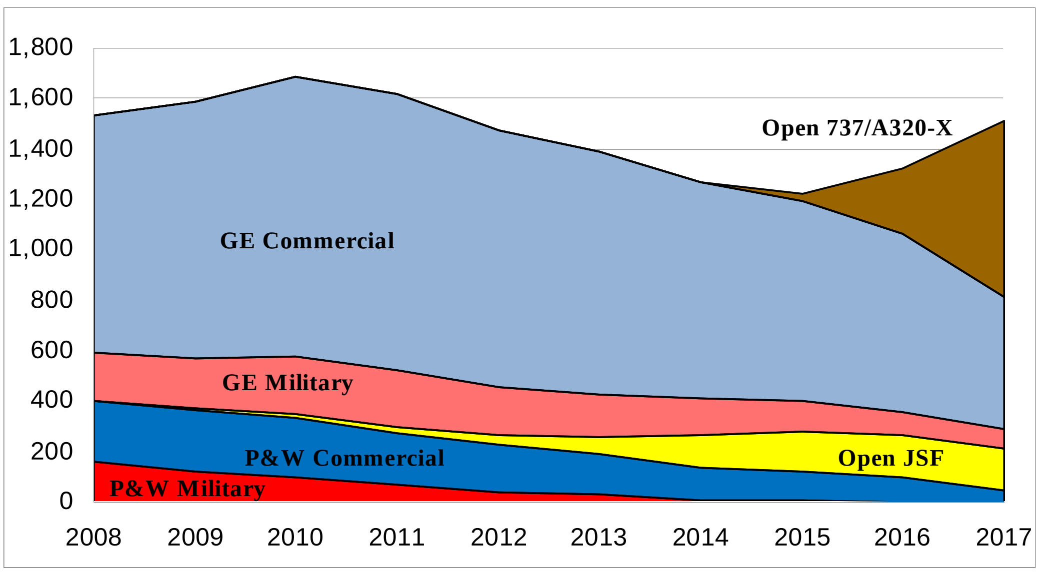
[80] Institute for Defense Analyses Report: "Joint Strike Fighter (JSF) Engine Cost Analysis: Final Report," July 2007, p. 87.

[81] "JSF Alternate Engine Decision" Briefing. OSD/PA&E. February 27, 2006.

The industrial base issues discussed and debated in hearings and other public fora have focused on whether a single supplier of fighter aircraft engine will result in costlier engines over time and whether reliable access to engines and spare parts might be jeopardized. The root of this question is what effect canceling the F136 engine will have on GE's ability to continue to compete in the high performance fighter aircraft engine business. Currently, the only U.S. manufacturers of fighter aircraft engines are P&W and GE.[82]

GE is a dominant player in the large, commercial aircraft engine market. By most estimates, GE has captured approximately 50% of this market (**Figure 2** shows GE's large engine position in relation to P&W's).[83] GE's current business in building and supporting high-thrust, high-performance, fighter aircraft engines is more modest. Currently, GE builds and maintains engines (F400 series) for the Navy's 462 F/A-18E/F *Super Hornet*s. It is expected to also build engines for the Navy's 90 EA-18G *Growlers*. GE supports the F110 series of engines for domestic and international clients. Finally, GE may be competitive in engine competitions for large unmanned aerial vehicles (UAVs).

Figure 2. GE/P&W Large Engine Forecasted Unit Production



Source: The Teal Group, May 9, 2008.

It appears that if the F136 were cancelled, GE's fighter aircraft design and manufacturing capabilities would not disappear immediately. The business outlined

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[82] However, as previously noted, Rolls Royce will be opening up a new plant in Virginia in 2009 that, in part, is planned to support their work in the F136.

[83] A majority of GE's commercial sales come from the CFM56 engine. Since GE has a 50% share of the CFM56 with France's Snecma, the Teal Group reduced GE's commercial CFM56 numbers by half. This methodology was used with other joint engine ventures. The future engine for the 737 and A320-X is still undecided between GE, P&W and Rolls Royce. However, the Teal Group accounted for the KC-45 competition by awarding its engines to GE.

above is likely sufficient to maintain GE's design teams, engineers, and assembly line workers, and much technology and expertise can be extracted from the commercial business lines. GE's own experience during the Great Engine War shows that a company on the periphery of a business area can "catch up," and beat an incumbent in head-to-head competition, even if that incumbent had been producing a particular type of engines for a decade.

Each of the three congressionally mandated studies commented on the effects to the industrial base. The CAIG and IDA both noted GE's dominance in the commercial engine market. The CAIG study noted that GE produced 1,000 commercial engines in 2007, compared to 220 commercial engines for P&W.[84] Additionally, the CAIG noted that P&W is highly dependent on military sales (~50% of direct sales in 2006) vice GE (~15%).[85] While there appears to be no significant loss of overall engineering talent at either manufacturer, the CAIG highlighted that ~200 GE military jet engineers would be unable to transfer skills to GE's commercial engines if the F136 engine was terminated.

IDA provided more in-depth analysis on the effects to the industrial base in their final report. While they concluded that the U.S. industrial base may not be "irreparably harmed" if the F136 engine is terminated, they expressed reservations in DOD placing all of its fighter engine production with a firm that has a weak position in the commercial marketplace.[86] IDA felt that a firm with a weak commercial marketplace presence would have fewer resources that could be leveraged for use on DOD products. IDA also examined the top suppliers of components for the F136 and determined that it is "unlikely that any supplier would exit the domestic industrial base because of F136 termination."[87] Overall, IDA concluded that the U.S. industrial base would be stronger as a result of an active F136 program.

One defense analyst, however, postulated that GE's current commercial market dominance over P&W could actually weaken the industrial base if GE was to secure a sizable share of the JSF engine business.[88] This analyst noted that GE, from 2007 to 2016, is expected to produce more engines for the F/A-18 than P&W will for all of the fighter aircraft it supports (F-15, F-16, F-22, and F-35).[89] The Teal Group's analysis appears to back up this claim and Figure 3 shows the forecasted value of GE's dominance in large engine production. Additionally, other than UAVs, the only other potential market for a fighter engine derivative appears to be the Next

[84] OSD Cost Analysis Improvement Group Report (v6), "F-35/JSF Alternate Engine Acquisition and Independent Cost Analyses," March 15, 2007, Slide 44.

[85] Ibid.

[86] IDA JSF Final Report, p. 169.

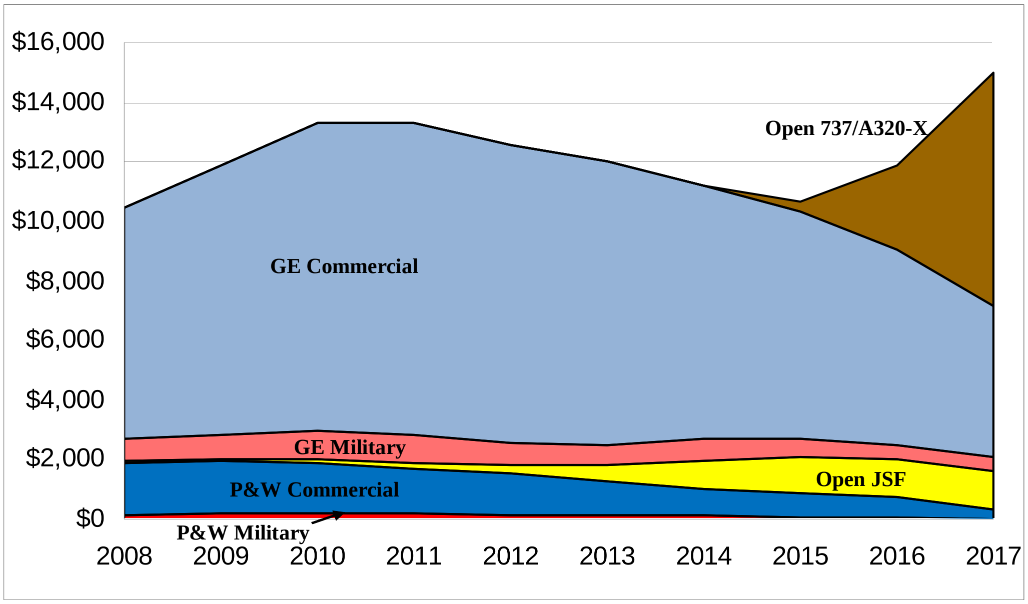
[87] Ibid., p. 165.

[88] Loren Thompson. "Powering JSF — One Engine Is Enough." *Lexington Institute*, January 2008, p. 14.

[89] Ibid., p. 15.

Generation Bomber due to be produced by the end of the next decade. Therefore, JSF engine contract success could have a profound effect of P&W's "bottom line."

Figure 3. GE/P&W Large Engine Forecasted Value (in $ Millions)



Source: The Teal Group, May 9, 2008.
Note: The same methodology was used by the Teal Group as was used in the forecasted unit production figure.

Additional industrial base issues have not yet been widely debated, but may also inform decisions on the future of the F136. One issue concerns export and competitiveness. The JSF is a centerpiece of the federal government's fighter aircraft policy. Since the program's beginning, the desire to produce a cost-effective, multirole aircraft appears to have been shaped by consideration of what the international market would bear.[90] The F-35 is designed as an export aircraft, and one that is hoped to leverage the international success of the F-16 Falcon (another cost effective, single engine, multirole fighter) to perpetuate U.S. dominance in this market. Foreign participation in the JSF program was sought to defray development costs, but also to "prime the pump" for export.[91]

A key question appears to be whether the JSF will achieve the same export success with one engine-type as it might with two. Some argue that the F-16's export success is directly attributable to having two engine types: "The F-16 became a much more exportable aircraft when GE and Pratt were killing each other in the international market. So, if you are selling these JSF's and you have got one

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[90] See for instance John Tirpak. "World Market Forces Improved Military Exports." *Aviation Week & Space Technology*. February 14, 1994. John Morrocco. "No JAST Prototypes to Fly Until After 2000." *Aviation Week & Space Technology*. December 13, 1993, and "Brits Visit JAST to Position for Next Round of Contracts." *Aerospace Daily*. June 1, 1994.

[91] "Australia, Belgium Enter Joint Strike Fighter Program as EMD Partners," Inside the Air Force, April 21, 2000.

engine...that reduces the attractiveness to these international customers..."[92] Singapore and South Korea have both selected the GE F110 engine to power their F-15 *Eagles*, and Saudi Arabia is giving serious consideration to re-engining its F-15s with GE engines. These decisions contrast with U.S. Air Force decisions to power its *Eagles* with P&W engines. Further, while GE engines power a large fraction of USAF F-16 *Falcons*, P&W engine sales to international F-16 customers have dominated GE sales. This background lends credence to the suggestion that competition in engine selection can enhance U.S. fighter aircraft export success.

Would cancelling the F136 and the attendant competition with the F135 adversely affect potential future advances in engine performance, reliability, and maintainability? If so, might this be at the expense of U.S. competitiveness? Some of those who participated in, or studied the "Great Engine War" assert that the competition between GE and P&W made *both* companies better and "proved invaluable to future engine development."[93]

The economic stakes in international fighter engine competition appear to be high. U.S. companies face competition from France, Sweden, Russia, and a European consortium of companies, and it is argued that some of these governments heavily subsidize their aerospace industries. Aerospace is an important export for the United States. Despite this competition, aerospace has at times provided the U.S. economy with its highest trade surplus.[94] Many observers project that the size of the international market for fighter aircraft will remain high for the next decade, after which it may peak and then decline.[95]

Acquisition Reform and Accountability

The final point one might make about the potential termination of the F136 pertains to acquisition reform, or "good government."[96] Congress has held multiple hearings on defense acquisition reform, and members have consistently expressed

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[92] Carlo Munoz. "Congress, Defense Department Square Off Over Second JSF Engine." *Inside the Air Force.* March 3, 2006.

[93] Maj. John Nix and Maj. Riley Shelnutt. "Behind the Alternate Fighter Engine Competition." *Aerospace America.* May 1984.

[94] "The trade surplus generated by aerospace foreign trade in 2005 totaled $37 billion. With an $8.4 billion increase in exports and $2 billion rise in imports, the industry's trade surplus expanded $6.4 billion. The aerospace trade balance, before its sharp rise this year and last, had fallen $14 billion from its $41 billion peak in 1998 due to $12 billion fewer exports and $2 billion more imports. In 2004, the latest year of comparative data, the U.S. aerospace industry posted the highest trade balance of all industry categories. (emphasis added)." *2005 Year-End Review and 2006 Forecast — An Analysis*. David H. Napier, Director, Aerospace Research Center. Aerospace Industries Association.

[95] "Market Overview: Fighter/Attack Aircraft." *World Military & Civil Aircraft Briefing.* Teal Group Inc. (Fairfax, VA) February 2006.

[96] For example, Air Land Subcommittee of the Senate Armed Services Committee, November 15, 2005, and Readiness and Management Support Subcommittee of the Senate Armed Services Committee, November 9, 2005.

concern about perceived shortcomings in the current acquisition system, or a lack of personal accountability in acquisition decisions. As Congress has tried to determine and correct the root causes of growing weapon system cost growth it has heard from witnesses a litany of problems such as funding instability, unrealistic requirements, poorly structured contractor incentives, too much reliance on lead system integrators, and the improper use of commercial contracts to purchase military items.

In this context, many observers believe that the competition during the "Great Engine War" conferred a number of benefits to government that today's acquisition officials would have a difficult time duplicating. For example, prior to the first contract award, the Air Force demanded that GE and P&W provide six years of cost projections to include the production of engines, but also the price of support equipment, spare engines, technical data and dual sourcing data and second sourcing data for operations and support. The contractors were held to these cost projections for six years: the Air Force let six years of firm-fixed price, or "not-to-exceed" contracts from the first production lot. Prior to the "Great Engine War," government had succeeded in negotiating firm-fixed price contracts only after the engine had been operating in the field for several years. Never before had contractors agreed to provide cost projections into the future, and contracts were typically for production only, not O&S work.

By requiring GE and P&W to compete for annual production and O&S work, DOD may have reaped a number of benefits such as better contract terms and conditions, better warranties to assure engine quality, consistency, and long term stability of support.[97] Further, after competition was introduced, the incumbent (P&W) offered "engine improvements to the Air Force earlier than the Air Force had been led to expect without the competition."[98] To avoid potential disruptions in production, and to protect itself against price gouging, DOD "required (each contractor) to provide his plan for providing dual sources of critical parts. These separately priced options in the proposals would allow the Government to reprocure spare parts from sources other than the prime contractors."[99]

Successfully orchestrating the "Great Engine War" in the mid-1980s required a considerable amount of effort and skill by Air Force leaders. It is unclear whether today's environment would allow, or whether DOD leadership would be able to exploit the JSF Alternate Engine competition as effectively as Air Force leaders in the past.

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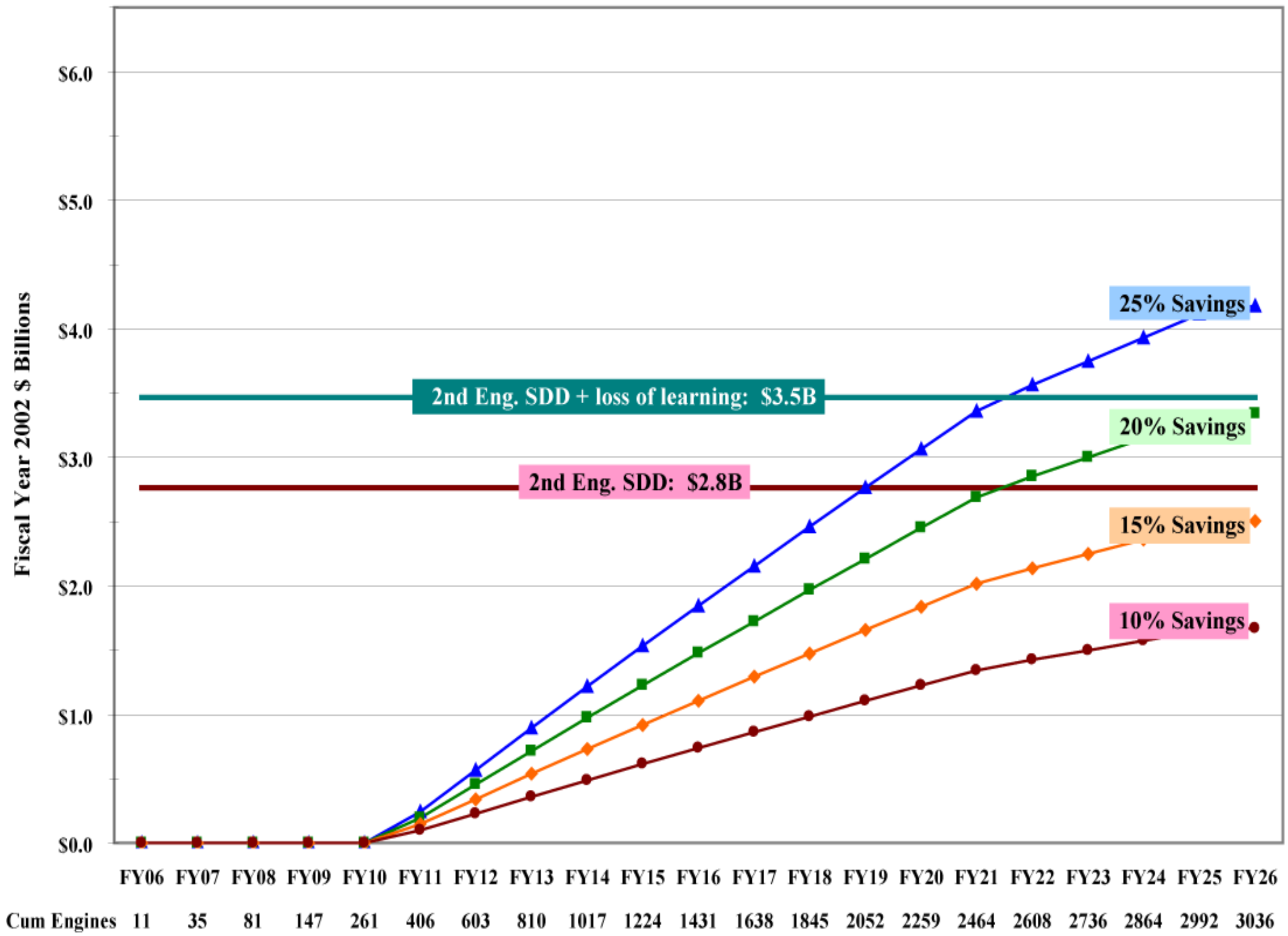
[97] U.S. Congress, House, Committee on Armed Services, *Air Force Alternative Fighter Engine, Hearings before the Subcommittee on Procurement and Military Nuclear systems*, 98th Cong. 2nd Sess., March 8, 1984.

[98] Robert W. Drewes. *The Air Force and the Great Engine War*. NDU Press (Washington, DC) 1987.

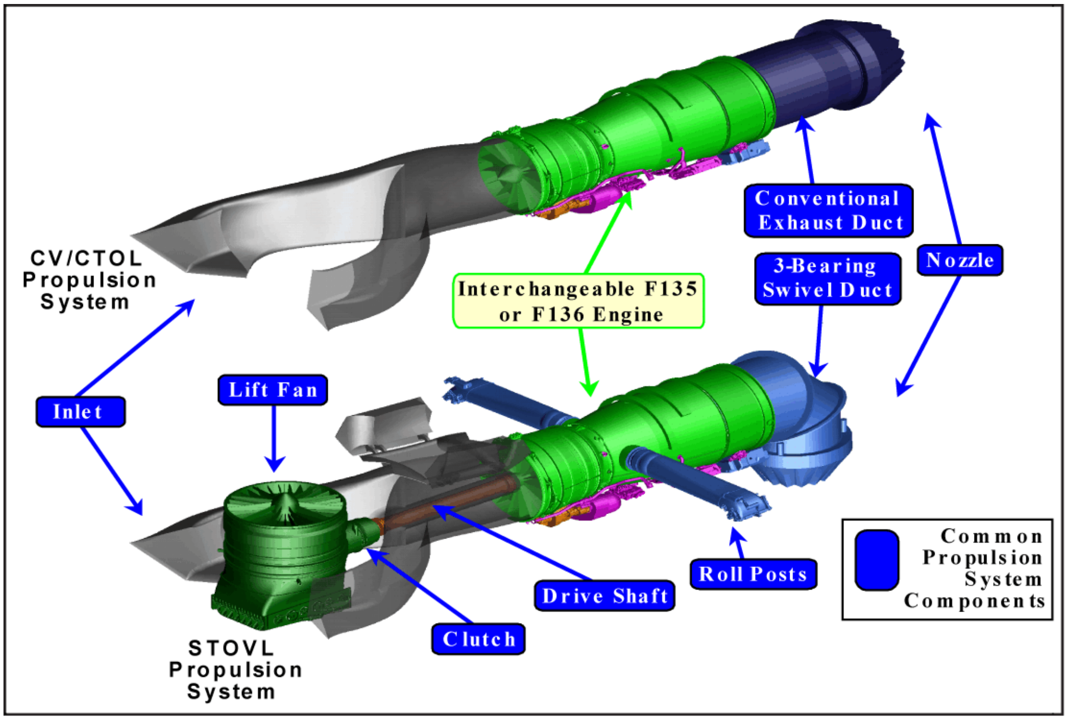
[99] Prepared Statement of Hon. Thomas Cooper. *Air Force Alternative Fighter Engine, Hearings* OpCit.

Appendix A. DOD F136 Cost Analysis



Source: PMAG 2002.

Appendix B. F-35 Engine Components



Source: JSF Engine Second Source Executive Summary. Whitney, Bradley, and Brown, December 20, 2006.