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SENATE ARMED SERVICES COMMITTEE

**STATEMENT OF**

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**BEFORE THE**

**SENATE ARMED SERVICES COMMITTEE**  
**AIRLAND SUBCOMMITTEE**

**HEARING ON AIR FORCE AND NAVY**  
**TACTICAL AVIATION PROGRAMS IN THE**  
**FY2007 DEFENSE AUTHORIZATION REQUEST**  
**AND THE FUTURE YEARS DEFENSE PLAN**

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## PANEL 1 STATEMENT

### Proposed F-22A *Raptor* Funding Strategy

Mr. Chairman, distinguished members of the subcommittee, thank you for inviting me to speak to you today about the F-22A. As you requested, my testimony will address the Air Force's proposed new funding strategy for the F-22A, and its plan to proceed with a multi-year procurement of 60 F-22A aircraft.

#### Introduction

As part of its FY2007 budget request, the Department of Defense (DoD) has proposed a change in how it plans to fund its remaining production of the F-22A *Raptor*, which in its parlance is "non-traditional, but executable."<sup>1</sup> The new strategy is complex, but can be described in a simplified way. DoD proposes to add an additional production lot, and to stretch the funding of its final 60 *Raptors* over an additional two year period (from FY08 to FY10). This incremental funding will reduce the average annual rate of procurement, and split the funding of annual production over a two year period (sub-assembly activities are funded in the first year, those sub-assemblies then transition to final assembly to create a complete aircraft in the second year). The Air Force also desires authority to enter into a multiyear procurement (MYP) contract, and a reprogramming of FY06 funds to execute an economic order quantity (EOQ) purchase prior to MYP authority. This revised strategy is expected to increase program costs at least \$930 million more than the program's cost estimate under the FY2006 plan.<sup>2</sup>

The Defense Department expects this plan would enable it to purchase four additional aircraft (for a total of 183), and extend the F-22A production line approximately one year, to reduce the gap between F-22A and F-35 production. Secretary of the Air Force Michael Wynne has testified to the full committee that "it is not in our nation's interest to terminate this fifth generation fighter [the F-22A] until we get access to another fifth generation fighter [the JSF]." Mr. Wynne's principal concern was that the United States might get into an "hot engagement" without either the F-22A or the JSF in production.<sup>3</sup>

The Defense Department cannot pursue this new funding strategy without congressional approval. Specifically, for this plan to move forward, DoD needs Congress to 1) grant it approval to negotiate an MYP contract with Lockheed Martin for the final three production lots, 2) grant it the authority to reprogram funds to make an economic order of quantity (EOQ) purchase in FY2006, and 3) approve the plan to incrementally fund the last 60 aircraft.

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<sup>1</sup>USAF Briefing on F-22A New Funding Strategy and Multiyear Procurement. Provided to CRS on March 2, 2006 by SAF LLW.

<sup>2</sup> FY 2006 and FY2007 Budget Estimates. AIRCRAFT PROCUREMENT AIR FORCE OPR: SAF/FMB. VOLUME I. U.S. Air Force.

<sup>3</sup>Hearing of the Senate Armed Services Committee on the Defense Authorization Request for Fiscal Year 2007 and the Future Years Defense Program. March 2, 2006.

## Complications

A number of factors may complicate DoD's ability to secure congressional approval of its "unorthodox plan" for the F-22A. For example, the F-22A program has experienced noteworthy turbulence between the FY05 and FY07 budget requests. Total program budget, annual budget requests, total inventory, annual procurement rate, and program duration have all changed. These changes may engender closer scrutiny than is customary of the underlying criteria for MYP authority.

Considering the changes to the F-22A program that have occurred, and changes which are being proposed, some may question the Air Force's ability to comply with some provisions of 10 USC 2306b(a), including provision (2) "That the minimum need for the property to be purchased is expected to remain substantially unchanged during the contemplated contract period in terms of production rate, procurement rate, and total quantities." and (3) "That there is a reasonable expectation that throughout the contemplated contract period the head of the agency will request funding for the contract at the level required to avoid contract cancellation."

A further complication may be a problem with sections of the F-22A's titanium "forward boom frame" (a series of load-bearing structures within the aircraft's fuselage, located between the engine and the wing) which was discovered by the manufacturer in December 2005. 10 USC 2306b(a) (4) requires that "There is a stable design for the property to be acquired and that the technical risks associated with such property are not excessive." Air Force officials say that the cause of the problem has been identified, and is not expected to affect any aircraft built after Lot 5. Air Force officials say that "Neither a redesign nor a retrofit are expected at this time."<sup>4</sup> However, Air Force officials also note this issue is still being evaluated, so making conclusive statements on potential ramifications may be premature.<sup>5</sup> Further, 91 aircraft were potentially affected by this problem. Inspecting these aircraft and taking corrective action, if any, may require substantial time and effort that was previously unforeseen.

Even if this potential flaw is easily resolved, some may raise questions about how this problem was made public. The Air Force briefed committee and other congressional staff on the F-22A's proposed funding strategy on February 22, 2006 and March 13, 2006, but did not mention the potential flaw in either briefing. Yet the potential flaw was discovered in December 2005. Were Air Force leaders unaware of this potential problem in February and March? Or, on the other hand, were Air Force leaders aware of this problem when they briefed congressional staff, and chose not to mention it? If so, this may suggest a lack of disclosure and transparency on the Air Force's part. Questions may remain on whether other problems associated with F-22A manufacture may emerge.

Another complication for the Air Force is the proposed incremental funding of F-22A procurement. Section 8008 of the FY2006 Defense Appropriations Act (PL 109-148) states that multiyear procurement must be based on "full funding of units to be procured through the contract." Supporting legislation, such as H.R. 4613 (H.Rept.108-553 of June 18, 2004) make clear that some appropriators find incremental funding to be incompatible with MYP contracts: "the Committee directs these requirements be met before future multiyear production contracts can be entered into: (1) Multiyear contracts must follow full funding policies and not be used as vehicles for incrementally funding procurement..." Some Members of Congress have already expressed concern

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<sup>4</sup>"Bullet Background Paper on F-22A Forward Boom Heat Treatment Issue." March 16, 2006. U.S. Air Force.

<sup>5</sup>Tony Capaccio. "Lockheed F-22A May Have Flaw Forcing Redesign, Rep. Young Says." *Bloomberg News Service*. March 15, 2006.

over the proposed F-22A funding strategy, and specifically singled out the incremental funding as objectionable.<sup>6</sup>

Air Force leaders are candid about the unorthodoxy of this proposal, and that it may have a difficult time gaining consensus among all parties involved in this decision. Air Force leaders describe this strategy as a “one time opportunity” to save money and to reduce risk.

## Issues

The issues associated with this proposed funding strategy lend themselves to a simple cost benefit calculation: what are the potential risks, who is taking the risks, who benefits, and how great are the potential benefits? This proposal may present a number of risks regarding the full funding principle and the question of “tying the hands of future Congresses.” For example, incremental funding appears to obligate the government to spend money that has not been appropriated. If the Congress were to cancel the F-22A program under annual funding it would have a “useable end item.” If it were to terminate the F-22A program at the end of a year when the sub-assembly of an F-22A production lot were completed, then the U.S. government would take possession of half-completed aircraft. To get any benefit from these incomplete aircraft, the government would have to spend more money to complete manufacture.

Air Force officials maintain that the chances of the F-22A encountering production problems at this stage are remote. Over 100 aircraft have been manufactured, and the aircraft’s design is mature and stable. Further, they argue that “half-finished” aircraft are not useless. They could be broken into piece parts and used to re-supply the F-22A fleet. This may be true, but it is likely that a cost penalty would be incurred by acquiring piece parts in this way. The prime contractor is being paid to build an airplane, not supply parts. Presumably, some of the cost of building these “half-finished” aircraft would be to cover assembly line overhead, and workers’ salaries, for example. These costs would be absent from parts purchased directly from a supplier.

Another potential risk is that the potential cost savings from the EOQ purchases and MYP contract (if approved) would not suffice to offset “upward cost pressure” caused by the reduced annual rate of F-22A production. Building 20 aircraft per year is appreciably fewer than the most efficient rate of production, which is estimated to be 32 aircraft per year.<sup>7</sup> The Air Force has not yet calculated how great the “upward cost pressure” will be. Again, it may be that the Air Force will require additional funds in the future to execute this proposed funding plan.

Some would see a more general risk in setting this precedent. The Air Force says that this proposed strategy is a “one time opportunity,” to reduce risk and to save money. The F-22A production line is drawing to a close, they say, and the Air Force won’t ask for such exceptions again. The F-35 JSF program, however, could potentially be delayed further. In that case, and based on the arguments made by DoD in support of this funding strategy, DoD could plausibly return to Congress in years hence and request more money to extend F-22A production to close the widening gap between it and JSF production. If the Air Force were successful in securing its requested waivers from Congress, the other Services may be motivated to seek similar concessions from

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<sup>6</sup>Rep. Duncan Hunter. *Opening Statement*. Hearing of the Senate Armed Services Committee on the Defense Authorization Request for Fiscal Year 2007 and the Future Years Defense Program. March 2, 2006.

<sup>7</sup>Under the previous funding strategy, the Air Force would have funded procurement of 29 aircraft in FY07 and 27 aircraft in FY08, closer to the more efficient rate of 32 per year.

Congress on their high priority procurement programs. If approved, this funding strategy may be cited by future DoD leaders as a precedent. Rep. Duncan Hunter, stated that the Air Force is “asking us to approve incremental funding for the F-22A, a precedent in and of itself,” and that he wished to understand “how we’ve arrived at this very unusual, precedent setting funding strategy.”<sup>8</sup>

The Air Force does not have a history of requesting incremental funding. This may be its first such request. At one point, requesting incremental funding in the Navy was also unusual. Today it has become common. For example after the Navy’s LHD-6 program received incremental funding in FY1993 and FY1994, the instances of incremental funding in Navy ship building appeared to accelerate. Since the mid 1990s, the LHD-8, LHA-6, CVN-21 and DDX programs have either been incrementally funded, or incremental funding has been proposed. As a final example of how the Services cite precedent to justify unorthodox requests, in 2001, Navy officials requested the use of advance appropriations for Navy ship procurement, noting that this funding approach had been used by several federal agencies other than DOD.<sup>9</sup>

The primary benefit that Air Force leaders say will result from this unorthodox plan is that by adding a 9<sup>th</sup> production lot to the F-22A program, the assembly line will remain open for a longer period of time. The Air Force says that this will reduce the potential gap between the end of F-22A production and the beginning of F-35 production. DoD believes that, as Air Force Secretary Wynne testified, it is in the nation’s interests to maintain a continuous production of advanced fighter aircraft in case we encounter a “hot engagement.”

This rationale may sound reasonable, but questions persist about how beneficial such continuous production may be, and whether these potential benefits merit the potential risks involved. The need for extending the F-22A production line has already been the subject of congressional scrutiny. At a March 1, 2006 hearing of the House Armed Services Committee, Chairman Duncan Hunter asked:

If there was a need to have a fifth generation fighter production line open, why the decision was made last year to cut the F-22 production line and then this year reverse that decision and extend the production, in both cases producing about the same number of aircraft, only now for a billion dollars more in program cost?<sup>10</sup>

It is unclear what immediate value keeping the F-22A production line open would have in a crisis. If, for example, the United States found itself unexpectedly drawn into major conflict and a larger inventory of *Raptors* were desired, it does not appear likely that the manufacturer could rapidly produce additional aircraft in large numbers. Due to the need to appropriate “long-lead” items, such as titanium, and to procure in advance other aircraft components, it takes between three to four years to build a production lot of F-22As from start to finish.<sup>11</sup> Even if large numbers of aircraft were rapidly produced, pilots for these aircraft, and maintenance personnel would need to be trained and organized. Tools, supplies, and spare parts would likely need to be acquired. How long does DoD envision such an “hot engagement” to last? The most intense and demanding air combat in recent operations has been measured in days and weeks, not in months or years.

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<sup>8</sup>Rep. Duncan Hunter. *Opening Statement*. OpCit.

<sup>9</sup>CRS Report RL32776. *Navy Ship Procurement: Alternative Funding Approaches*. Ronald O’Rourke.

<sup>10</sup>Rep. Duncan Hunter. *Opening Statement*. OpCit.

<sup>11</sup> Conversation with SAF/LLW. March 14, 2006.

If the F-22A production line were to replace lost capability rather than add to fielded capability, it is unclear what scenario DoD envisions that would result in such heavy attrition of the *Raptor*. The F-22A has been touted as the only aircraft that can operate in the most threatening wartime environments from “day one.” Air Force leaders have stated that the F-22A will be the aircraft that will “kick down the door,” by eliminating the most challenging threats and thus enable “persistence” forces like the F-35 JSF and “legacy” forces like the F/A-18E/F to operate safely and effectively. If the Air Force is concerned that the F-22A could suffer such extensive attrition in a near-term conflict (circa 2011), that keeping the production line open is a prudent measure, one might ask whether the Air Force has overestimated the *Raptor*’s capabilities.

Air Force leaders assert that they require 381 *Raptors* not 183. Consequently, keeping the production line open longer does not reflect a lack of confidence on their part. Instead it simply preserves the option of purchasing more aircraft in the future if budgets and circumstances permit, which would reduce the gap between the number of F-22As the Air Force needs, and the number it can currently afford. Although the Air Force has been consistent in recent years in stating its requirement for 381 F-22As, it could also be said that DoD must be satisfied with the currently planned *Raptor* inventory, or else it would not have cut \$10.5 billion from the F-22A budget.

A final question addresses how effective the proposed F-22A funding strategy may be in facilitating the continuous production of DoD’s 5<sup>th</sup> generation fighter aircraft. Under last year’s plan, F-22A production would end in December 2010. According to the JSF Joint Program Office (JPO), 21 JSF aircraft are planned for delivery to DoD by that date.<sup>12</sup> These aircraft would enter production in 2008 to make a 2010 delivery<sup>13</sup>. Thus, it appears that under the old F-22A funding strategy, JSF and F-22A production overlapped by two years and that there is no break in the production of 5<sup>th</sup> generation fighter aircraft.

Under the new F-22A funding strategy, production would end in December 2011. It appears that the only material difference between the old and proposed plans, in terms of overlapping with JSF production, is that 71 F-35s are expected to be delivered by December 2011; 50 more than under the old plan. In terms of schedule, however, the proposed funding plan would bring F-22A production one year closer to the Marine Corps’ planned JSF initial operational capability (IOC) in March 2012, and the Navy’s and Air Force’s planned IOC in 2013.

## **Conclusion**

Mr. Chairman, this concludes my remarks on the F-22A. Thank you for the opportunity to appear before you and discuss this important issue. I look forward to addressing any questions you or the committee may have.

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<sup>12</sup> Email from Office of the Secretary of Defense, Legislative Affairs. March 13, 2006.

<sup>13</sup> Technically, production will begin once advance appropriations for long-lead items is obligated. This is expected to occur by the second quarter of 2006.

## PANEL 2 STATEMENT

### Cancellation of F136 Alternate Engine for F-35 Joint Strike Fighter

Mr. Chairman, distinguished members of the subcommittee, thank you for inviting me to speak to you today about the F136 Alternative Engine Program. As you requested, my testimony will address the F136 program and the Air Force's analysis and conclusions recommending its termination.

#### Introduction

The Department of Defense's (DoD) FY2007 budget proposes to cancel the F136 alternate engine for the F-35 Joint Strike Fighter, a program which was initiated by Congress in the FY1996 Defense Authorization Act, and which has received consistent congressional support since its inception. The reason cited for this proposed cancellation was that it would save \$1.8 billion over the Future Years Defense Plan (FYDP), yet entail little operational risk.

Some DoD leaders, however, have expressed mixed feelings about this decision. On February 16, 2006 Secretary of Defense Rumsfeld testified that the merits of terminating the F136 were "clearly debatable."<sup>14</sup> On March 1, 2006, Air Force Secretary Michael Wynne testified that he was worried about the "downstream effects" of this decision.<sup>15</sup> These statements may suggest that there is a lack of consensus within DoD regarding this course of action, or it may simply presage the congressional scrutiny to follow.

#### 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)<sup>16</sup> 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' 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 become known as "The Great Engine War" that ran from 1984-to-1994. The Great Engine War describes the competition between Pratt & Whitney (PW) and General Electric (GE) to produce engines (the F100 and F110 respectively) to power the Air Force's F-16 *Falcon* and F-15 *Eagle* fighter aircraft. This competition was held annually between 1984 and 1994 to produce and maintain these engines for the Air Force. After 1994, PW 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

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<sup>14</sup>Michael Bruno. "House defense appropriators push back on JSF engine." *Aerospace Daily & Defense Report*. February 17, 2006.

<sup>15</sup>CONGRESSIONAL TRANSCRIPTS. *Reuters*. Congressional Hearings. March 1, 2006. House Armed Services Committee Holds Hearing on FY 2007 Budget: Air Force.

<sup>16</sup>At that time, the JSF program was The Joint Advanced Strike Technology Program ( JAST).

controversial. Many extolled the advantages of competition and the benefits it conferred to DoD and the taxpayer.

The Great Engine War's roots extend well before 1984. Most observers credit Congress with initiating this competition by providing funds in FY1976 and FY1979 to develop a new engine that might serve to power the Navy's F-14 *Tomcat*, or the Air Force's F-15 and F-16. 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 critics say that "There is no evidence that the F-16 engine competition saved money."<sup>17</sup>

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."<sup>18</sup> 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 multi-year contracts from a single source.

It is not clear if the decision to terminate F136 was based on its merits or if it was the result of tradeoffs in a budget cutting process. However, the program is clearly handicapped in budget considerations by the fact that its benefits won't be realized for a decade, while much of its costs are immediate.

## Issues

As DoD has noted, cancelling the F-136 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 reform DoD's acquisition system and conform to higher standards of accountability.

This testimony addresses these issues in detail, except the potential impact on relations with key allied countries. However, it is worth briefly noting that friction currently exists 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.<sup>19</sup> These countries have threatened to reduce their participation in

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<sup>17</sup>"Joint Strike Fighter - Engine Development," (JSF Talk-3) *Talking Points*. Pratt & Whitney. February 23, 2006.

<sup>18</sup>Richard Mullen. "Cutting JSF Engine Was Navy Idea: Wynne." *Defense Today Instant Update*. March 2, 2006.

<sup>19</sup>"Norway Signs Industrial Partnership with Eurofighter Consortium," *Defense Daily*, Jan. 29, 2003. Joris Janssen Lok, "Frustration Mounts Among JSF Partners," *Jane's Defense Weekly*. Mar. 24, 2004. Thomas Dodd, "Danish Companies Consider Quitting JSF Programme," *Jane's Defence Weekly*, Jan. 9, 2004.

(continued...)

the program, or purchase the Eurofighter *Typhoon* 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. 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. As the full Committee has recently heard, the UK has warned that it may cancel its participation in the JSF if its concerns are not satisfactorily addressed.

**Operational Risk.** DoD officials argue that terminating the F136 poses little operational risk. The decision to pursue an alternate engine for F-14s, F-15, 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 pursued alternate engines not only for cost savings, but to improve engine performance, reliability, and to reduce operational risk. DoD argues that these same conditions do not exist today.

In a briefing provided to Congress<sup>20</sup>, the DoD Office of Program Analysis and Evaluation (PA&E) states that the F135 engine produced by Pratt & Whitney (PW) for the F-35 is performing well. The first F135 aircraft engine was delivered December 2005. Current F135 testing is "on track and successful," PA&E notes, and is 33% complete as of February 2006. Further, PA&E states that the F119 engine that PW produced for the F-22A Raptor, which served as the basis of the F135, is also performing well. It asserts that the F119 has performed well after roughly 18,000 flight hours, PA&E notes, and will achieve 100,000 flight hours by 2009. This briefing also notes that the F-22A Raptor and the F/A-18E/F *Super Hornet* rely on a sole source engine supplier (the PW F119 and GE F414 respectively), implying that the F-35 can likewise rely on a single engine manufacturer.

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. Presumably, using these tools will result in better-made engines that would encounter fewer problems during their lives, and will also provide the means of predicting or detecting engine problems before they occur. DoD and industry witnesses before the full Committee have noted that aircraft engines are more reliable today than there were in the past. (Some may argue that today's engines are more reliable than in the past due to the competitive pressures experienced by engine manufacturers in the 1984-1995 time frame.) As one yardstick, witnesses have noted that the Class A mishap rates for the single-engine F-16 as one example, have dropped from 10 per 100,000 hours to one per 100,000 hours.

Others who support DoD's decision to terminate the F136 argue that an alternate engine will not help mitigate risk. They say that there are no instances in the historical record of a fighter aircraft fleet being grounded by an engine defect. Engine problems, they say, are typically limited to a specific model, or engine series, or to a particular airfield or base.

A number of observations can be made regarding these arguments. First, the comparison between the F-22A and the F/A-18E/F and the F-35 may not be apt. Both the *Raptor* and the *Super Hornet* are equipped with two engines. The F-35 will have one engine. A single engine aircraft is

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<sup>19</sup>(...continued)

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, Nov. 10, 2004.

<sup>20</sup>"JSF Alternate Engine Decision" Briefing. OSD/PA&E. February 27, 2006.

inherently subject to higher risk than a two-engine aircraft, as the consequences of engine problems in the F-35 will be worse than for the F-22A or F/A-18E/F. As one simple datum to consider, between FY1990 and FY2004, the single-engine F-16 suffered 80 Class A engine-related mishaps for a rate of 1.31 per 100,000 flight hours. The twin-engine F-15 suffered 21 engine related Class A engine-related mishaps for a rate of .64 per 100,000 flight hours.<sup>21</sup> Mishap statistics must be used cautiously, however, when trying to support arguments about aircraft engine reliability. Many different factors contribute to military aviation safety and the improvements described in previous testimony. Because mishap rates have improved does not necessarily mean that improved engine reliability was the cause. Most safety experts attribute improvements in mishap rates over the past 30 years to the implementation of improved safety awareness techniques such as Operational Risk Management (ORM). Similarly, it is not clear that the F-15's two engines are the primary reason this aircraft has a mishap rate one-half that of the F-16. Interviews with safety professionals and military pilots, however, indicate a large majority believes two engines to be safer than one engine.<sup>22</sup>

Unlike the *Raptor* and *Super Hornet*, one of the F-35 variants will be powered by an engine capable of Vertical and Short Take off and Landings (VSTOL). The VSTOL engine will be more complex than the conventional engines and will be subject to different operational stresses and conditions. The AV-8B Harrier, the Marine Corps short take off and vertical landing (STOVL) fighter aircraft has one of the highest mishap rates of all military aircraft. Importantly, unlike most aircraft-types which are subject to mishaps most frequently through human error, two-thirds of AV-8B's mishaps are related to the aircraft materiel failures.<sup>23</sup> Further, the four primary material problems related to AV-8B mishaps reportedly are Engine, Flaps Controller, Nose Wheel Steering, and Ejection System.<sup>24</sup> It is to be hoped that the VSTOL JSF will improve upon the AV-8Bs safety record and engine problems. However, it appears optimistic to contend that engines generally, and VSTOL engine in particular, do not contribute to safety concerns.

A second point that might be made regarding DoD's risk assessment is that the experience with the F119 and F135 engines is still relatively modest. By the time the decision was made to divide engine production contracts between GE and PW in 1984, the PW F100 engine had accumulated 2,000,000 hours of operational service. Even with this extensive experience with the engine, over the following 25 years PW and the Air Force made numerous improvements to the engine as it competed for business with GE. By comparison, the 18,000 hours of testing appears to be a modest foundation to make projections of the F119's future performance.

It does not appear that there are any overt performance or reliability problems with today's fighter aircraft engines that an alternate engine would be required to remedy. However, it may be worth noting, that in the future, the JSF will be the only fighter aircraft in service. If any engine problems are encountered, the entire fighter aircraft fleet may be affected, not just one model of

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<sup>21</sup> Fighter/Attack Aircraft. Engine-Related Class A Mishaps. USAF Safety Center. [http://afsafety.af.mil/stats/e\\_stats\\_2.asp](http://afsafety.af.mil/stats/e_stats_2.asp).

<sup>22</sup> CRS Report for Congress RL31571. *Military Aviation Safety*. Christopher Bolkcom.

<sup>23</sup>Sandra Ervin. "Navy Aims to Curtail Aviation Mishaps Caused by Crew Error." *National Defense*. October 2000. *First annual report of the Harrier Review Panel (HaRP)*. USMC. 30 September 1998 Executive Summary. Chaired by Deputy Chief of Staff (Aviation), Lt.Gen. T. Dake . Since its introduction the AV-8B has outpaced all aircraft types with 68 (Now 77) Class A mishaps for a cumulative rate of 12.1 per 100,000 flight hours. The Class A mishap rate for the first model of the Harrier, the AV-8A, was 31.77 mishaps per 100,000 hours.

<sup>24</sup> Alan C. Miller and Kevin Sack. "The Widow Maker." *Los Angeles Times*. December 15, 2002.

aircraft. In 1984 when the decision was made to award engine production contracts to both contractors, the Air Force, Navy, and Marine Corps flew roughly 11 different models of combat aircraft.<sup>25</sup> While DoD was experiencing problems with some combat aircraft engines, it also had sufficient aircraft diversity that an F-4, for example, might be able to perform a mission if an F-14 or F-18 were grounded due to engine problems. DoD will not have this diversity in the future, so consequences of potential engine problems again appear to be more troubling than in the past.

DoD's statements about grounding aircraft may be incomplete. A number of aircraft has been grounded over the past five years, including the KC-135, C-130, and B-1B, and none of these groundings was for engine-related problems. However, aircraft *have* been grounded for engine-related problems. 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.<sup>26</sup> Further, aircraft groundings whether or not for engine-related problems may not occur often because as a matter of policy, the Services try not to ground aircraft. If aircraft are grounded, a positive action or finding must take place before the aircraft return to service. Instead, the Services try to "stand down" aircraft when safety is a concern. These stand downs are typically for a defined period of time and are either anticipatory, or in response to some general concerns. As one example, on March 6, 2006, the commander of Naval Air Forces directed a mandatory, half-day safety stand down for all naval aviation squadrons and detachments. Although safety stand downs for individual wings or squadrons take place more frequently, this was the first service-wide stand-down in four years.<sup>27</sup>

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, terrorist attacks, or natural disasters.

Finally, it may be noted that DoD statements on the potential risk of operating the F-35 with a single engine-type appear to be inconsistent, or potentially contradictory. For example, DoD's Office of Program Analysis & Evaluation (PA&E) claims that "Relying on single engine supplier incurs minimum operational risk." In the same document, PA&E notes that the JSF alternate engine offers "significant benefits" in readiness, reliability, availability, and protection from fleet grounding.<sup>28</sup> Logic suggests that if a course of action offers "significant benefit," the elimination of that course of action would elicit a negative or harmful effect. 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

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<sup>25</sup>Air Force: A-7D, A-10, F-4, F-15, F-16. Navy: A-6E, A-7E, F-4, F-14. Marine Corps: A-4M, A-6E, AV-8C, F-4N, F-18.

<sup>26</sup> Mark Oliva. "Pilots defend Harrier jet." *Stars and Stripes*. (Pacific Edition). January 19, 2003.

<sup>27</sup>"CNAF Directs Half-Day Stand-Down." Naval Safety Center. U.S.Navy. [http://www.safetycenter.navy.mil/articles/a-m/CNAF\\_directs\\_standdown.htm](http://www.safetycenter.navy.mil/articles/a-m/CNAF_directs_standdown.htm).

<sup>28</sup> JSF Alternate Engine Decision" Briefing. OSD/PA&E. February 27, 2006.

“I don't like to see our industrial base go to a single supplier.”<sup>29</sup>

**Cost and Savings.**<sup>30</sup> Many believe that estimating cost lends itself to quantitative analysis more than estimating risk. However, this may not be the case. The time lines involved in these estimates are long, the variables are numerous, and cost estimating tools are imperfect.<sup>31</sup> Like any quantitative assessment, assumptions made about the variables measured can influence significantly the analyses' output. When calculating the amount of competition-generated savings required to recoup the costs of developing the F136 engine, two variables can sway the analysis considerably: the amount of money being amortized over the life of the F-35, and the number of engines to be purchased. Additional assumptions and assertions can also affect the analysis. Therefore, costs and savings estimates by parties on *both sides* of the F136 debate may be matters of some subjectivity.<sup>32</sup>

Deputy Secretary of Defense Gordon England has written that “The Department’s analysis concluded that a second (engine) source would not yield program cost savings.”<sup>33</sup> Mr. England has also reiterated this position in recent testimony. The analysis that DoD shared with Congress and CRS on JSF Alternate Engine cost issues contained a single chart that depicts the output from its analysis, and a number of anecdotes and historical examples that DoD maintains support its analysis.

DoD’s “Break Even Analysis” chart is meant to show the percentage of savings required to “break even” (i.e. recoup F136 costs) over a 16 year period in which DoD purchases 3,036 JSF engines. If competition in the production of these engines were to result in 25% cost savings, DoD would recoup the F136 \$2.8 billion System Development and Demonstration (SDD) costs in FY2019 when the 2,259<sup>th</sup> engine is purchased. If 20% savings occurs, DoD will break even in FY2021. Fifteen percent savings will come close to \$2.8 billion (approximately \$2.6 billion) by the end of the production run, never fully recouping F136 SDD costs by DoD’s calculations. Thus, DoD argues that to fund an alternate engine for the F-35, must generate at least 15% cost savings to justify itself on a cost basis.

DoD states that this much cost savings is unlikely because its experience during the “Great Engine War,” and the competition between GE and PW for the Navy’s F404 business in the late

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<sup>29</sup>CONGRESSIONAL TRANSCRIPTS. *Reuters*. Congressional Hearings. March 1, 2006. House Armed Services Committee Holds Hearing on FY 2007 Budget: Air Force.

<sup>30</sup> To date, \$1.08 billion has been obligated to the F136 program. A \$2.4 billion contract awarded in August 2005 would have funded the program’s system development and demonstration phase, slated to run until September 2013. DoD estimates that if it cancels the F136 it could incur between \$50-\$70 million in termination costs and an increase of approximately \$100 million in the F135 program due to the need for additional flight test assets. Source: “Information Paper.” Department of Defense. February 27, 2006. Provided to CRS by SAF LLW.

<sup>31</sup> *Military Jet Engine Acquisition: Technology Basics and Cost-Estimating Methodology*. RAND. Santa Monica, CA. 2002. and *Factors Affecting the Use of Competition in Weapon System Acquisition*. RAND (Santa Monica, CA) February 1981. p.53 which noted that “the existing body of analysis has not provided an adequate set of management tools for estimating the benefits or the costs of competitive procurement.”

<sup>32</sup> The Navy’s F404 engine competition may serve as an example of the difficulties involved in estimating cost savings resulting from competition. A press account stated that “Although Navy officials were able to identify the direct costs of establishing a second source for the F404, they *could not estimate the total cost of keeping two production lines open*. (emphasis added)” “Navy Spent At Least \$58.6 Million To Set Up Second F404 Line.” *Aerospace Daily*. August 30, 1989.

<sup>33</sup> Cover letter. JSF Alternate Engine Decision” Briefing. OSD/PA&E. February 27, 2006.

1980s,<sup>34</sup> indicate that engine competition generates only “minimum cost benefit.”<sup>35</sup> Cost benefit is minimized DoD asserts because “Splitting the buy between two competitors can make production and support costs increase.” DoD cites reduced “learning curve effect,” decreased buying power for each source, and amortizing fixed costs over fewer units for each source, as specific cost pressures.<sup>36</sup>

On its “Break Even Analysis” chart, DoD expresses these projected cost increases as \$700 million that is added to the \$2.8 billion in SDD costs that must be recouped. To recoup the SDD costs *and* make up for this “loss of learning” caused by a second competitor, DoD argues that 25% savings will be required to break even by FY2021, and that 20% savings generated by competition will almost break even by the end of the production run in FY2026 (approximately \$3.4 billion).

Pratt & Whitney (PW) has offered a similar analysis, but using a slightly different methodology and different assumptions. PW estimates that the amount of money needed to be recouped through competition generated savings is \$3.5 billion, apparently including the \$1.08 billion spent on the F136 prior to SDD. PW estimates that 4,000 JSF engines will be purchased, but amortizes the \$3.5 billion over only the engines that GE might win in a competition. A 50% win rate, or 2,000 engines, is assumed for the analysis. By this methodology, GE would have to generate over \$1.7 million worth of savings per engine to pay for the cost of development. It is unreasonable to expect, PW argues, \$1.7 million worth of savings on a \$6 million engine.<sup>37</sup> During recent testimony before the full committee, a PW witness also made the point that engine life cycle costs such as component improvement, and mid-life upgrades would be doubled if a second engine were to be funded. Any potential savings from competition would need to defray these additional costs to justify a second engine on a cost basis.

There are a number of observations that can be made regarding DoD’s cost estimating methodology, and its underlying arguments. Perhaps the most important observation is on some of the assumptions made in DoD’s and PW’s analyses. In both analyses it appears that the number of engines over which the SDD costs is amortized may be too small, based on historical experience. Further, it can be argued that the \$3.5 billion figure cited by both studies as the F136 costs to be amortized, is too high. Individually, the assumptions made on the number of engines, and the amount of money to be recouped, make competition appear to be less cost effective. Together, these assumptions may lead to the conclusion that competition is without financial merit in this case.

DoD’s estimate of 3,036 JSF engines over which the SDD costs would be amortized appears to be too low because many more engines are typically purchased than the total number of aircraft. DoD currently plans to purchase a total of 2,443 F-35s, and international partners plan to purchase 733 for a combined purchase of 3,716 aircraft. Over the 20-30 year lifetime of a fighter aircraft, more engines and many spare parts will be purchased. DoD recognizes this, so it plans to purchase initial spare engines at 15% of the fleet for a total (366 for DoD, 110 for partners). More engines, however, will be needed.

A conservative and illustrative planning factor is that a single aircraft will require 2.5 engine

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<sup>34</sup> The Navy awarded PW approximately \$59 million starting in 1985 to initiate a competition between it and GE (the incumbent) for production of different F404 engine variants for the F/A-18 and other Navy aircraft.

<sup>35</sup>“JSF Alternate Engine Decision” Briefing. OSD/PA&E. February 27, 2006.

<sup>36</sup> *Ibid*

<sup>37</sup> “Joint Strike Fighter - Engine Development,” (JSF Talk-3) *Talking Points*. Pratt & Whitney. February 23, 2006.

equivalents (either whole engines, or piece parts) over its lifetime.<sup>38</sup> If this planning factor is applied to the JSF program, one can expect a total of 6,474 engines purchased for DoD and 8,417 engines total, *not including* additional potential future international sales. PW's figure of 2,000 engines appears to be low for similar reasons, but also because competition should decrease the cost of *both* engines, not just the alternate engine. So, SDD costs would be recouped by the cumulative cost savings of all engines produced, not just those awarded to GE.

A key assumption implicit in both DoD's and PW's analysis is that SDD costs are only amortized over engine *production*. PW and GE would annually compete to produce the F-35's engines, and also to support the engines over the 20-30 year life of the aircraft. A larger fraction of an aircraft engine's life cycle cost is attributed to support activities than to production. Therefore, it appears that both the DoD and the PW analysis ignore a considerable body of potential work over which the contractors would compete and potentially generate savings which could help defray up front SDD costs. Air Force officials who participated in the "Great Engine War" believe that cost savings from competition during operations and support (O&S) were considerably greater than cost savings from competition during engine production.<sup>39</sup>

It can be argued that PW's inclusion of \$1.08 billion in F136 costs to be recouped during competition is inappropriate because these are "sunk costs." No decision made today, or next year, will recoup them. If DoD were to cancel the F-136 program, it could recoup all of the \$2.8 billion awarded for SDD, minus termination liability. Thus, the savings from terminating the program can be weighed against the potential costs and savings of keeping it. It is noteworthy that DoD does not include this \$1.08 billion in its cost analysis.

DoD's assertion that costs to DoD increase by \$700 million when it funds a second engine producer because of a "loss of learning" appears to be central to DoD's claim that a second manufacturer does not save money. Yet, it is unclear how this "loss of learning" has been quantified, and whether this figure is offset by the competitive forces that can increase learning, productivity, and innovation. Similarly, DoD's argument that "splitting the buy between two competitors can make production and support costs increase" has not been substantiated in documents provided to Congress.

To support its "Break Even Analysis," DoD's states that it experienced only "minimum cost benefit from engine competition," during the Great Engine War. This assertion is at odds with statements made earlier by senior Air Force officials. Several sources estimate that through competition, the Air Force saved 21% (\$4 billion of an \$18.8 billion program) over the 20 year life cycle of the improved F100 and F110 engines compared to operating legacy F100 engines over the

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<sup>38</sup> Rough estimates of the number of engine equivalents will be required per aircraft over its lifetime were provided by Pratt & Whitney and GE. One set of estimates was calculated by adding the value of initial engine spares to the value of forecasted replenishment spares, divided by the unit recurring flyaway (URF) cost of the propulsion system. In the case of the JSF engines, this equation leads to rough planning factors of 2.44 engines for the Navy variant, 2.17 for the Air Force variant, and 2.59 for the Marine Corps variant. Clearly, assumptions on spares will affect the analyses results. A planning factor of 1.5 engine equivalents, for example, per aircraft will result in a smaller total purchase, and a planning factor of 3.0 will result in a larger total engine purchase.

<sup>39</sup> Telephone interview with Col. James Nelson (Ret.) Former Deputy for Propulsion, Aeronautical Systems Division, Air Force Systems Command. March 5, 2006.

same period of time.<sup>40</sup> It should be noted that the Air Force's estimate of \$4 billion in savings does not appear to account for all of the F110 development costs.<sup>41</sup> If these costs are also considered, the \$4 billion in savings due to competition may be closer to \$3.5 billion.

Also, the Navy's aborted F404 engine competition may not be the best cost analogy to today's potential JSF engine competition, because it reportedly was not pursued to save money. Navy spokespersons stated that Secretary of the Navy Lehman "opted to open the second F404 line to ensure 'that an adequate industrial mobilization base existed to meet the national defense needs and to promote competition. It was not based on projected cost savings.'"<sup>42</sup> Evaluating the F404 competition is complicated because PW reportedly was found guilty of illegally obtaining GE's confidential pricing data, and conspiring with Navy officials to defraud the government.<sup>43</sup> This may have played a more significant role in DoD's decision to terminate the competition than cost savings estimates.

**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.<sup>44</sup> 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.

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 PW and GE.

GE is a dominant player in the large, commercial aircraft engine market. By most estimates, GE has captured approximately 50% of this market. 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 planned inventory of 462 F/A-18E/F *Super Hornets*. It is expected to also build engines for the Navy's planned inventory of 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).

It appears that if the F136 were cancelled, GE's fighter aircraft design and manufacturing

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<sup>40</sup> Prepared Statement of Hon. Thomas Cooper. U.S. Congress, House, Committee on Armed Services, *Air Force Alternative Fighter Engine, Hearings before the Subcommittee on Procurement and Military Nuclear systems*, 98<sup>th</sup> Cong. 2<sup>nd</sup> Sess., March 8, 1984. *Point Paper on Air Force Alternate Fighter Engine (AFE) Competition*. Aeronautical Systems Division. Directorate of Development and Production, DCS/Research, Development and Acquisition. February 18, 1987.

<sup>41</sup> Donald L. Pilling. *Competition in Defense Procurement*. Brookings (Washington, DC) 1989. And telephone and email exchanges with GE representatives March 22, 2006.

<sup>42</sup> Statement by Naval Air Systems Command (NAVAIR) August 23, 1989, as cited in "Navy Spent At Least \$58.6 Million To Set Up Second F404 Line." *Aerospace Daily*. August 30, 1989.

<sup>43</sup> "United Technologies Admits 'Ill Wind' Role, Will Pay Fine." *Aviation Week & Space Technology*. September 7, 1992.

<sup>44</sup> "JSF Alternate Engine Decision" Briefing. OSD/PA&E. February 27, 2006.

capabilities would not peter out immediately. The business outlined above likely is sufficient to maintain GE's design teams, engineers, and assembly line workers, and much technology and expertise might 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.

If the F136 program were canceled today, and in, say 10 years time, DoD requested GE to design and build an alternate to the F135, GE might face noteworthy challenges. It already trails PW by three years of development, for example, and PW's lead would grow with each year GE was out of this business. GE's successful competition with PW in the Great Engine War was expedited by GE already having an engine (the F101) in the same thrust class as the PW F100. GE was developing the F101 for the B-1B bomber, and this work gave the F110 program considerable leverage.

GE does not have another engine in the same thrust class (~40,000 lbs) as the F136, and no other high performance fighter aircraft programs after the JSF appear to be in DoD plans. The F110 and F400 series engines that GE maintains are in a different class than the F136 and are the focus of maintenance and upgrade efforts, not design efforts. The leverage that GE's commercial engine business might offer to developing a new 40,000 lb thrust engine is unclear. Commercial engines share some qualities with fighter aircraft engines, but they are also very different. Commercial engines do not employ afterburners, or thrust vectoring, for example, and they are designed to meet fuel efficiency goals, not performance goals like fighter aircraft engines.

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, multi-role aircraft appears to have been shaped by consideration of what the international market would bear.<sup>45</sup> 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, multi-role 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.<sup>46</sup>

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 engine...that reduces the attractiveness to these international customers..."<sup>47</sup> 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 PW engines. Further, while GE engines

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<sup>45</sup> 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.

<sup>46</sup> "Australia, Belgium Enter Joint Strike Fighter Program as EMD Partners," *Inside the Air Force*, April 21, 2000.

<sup>47</sup> Carlo Munoz. "Congress, Defense Department Square Off Over Second JSF Engine." *Inside the Air Force*. March 3, 2006.

power a large fraction of USAF F-16 *Falcons*, PW 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? Many of those who participated in, or studied the “Great Engine War” assert that the competition between GE and PW made *both* companies better and “proved invaluable to future engine development.”<sup>48</sup>

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.<sup>49</sup> 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.<sup>50</sup> Thus, the importance of maintaining the competitiveness of the U.S. fighter aircraft engine industry may grow, if U.S. fighter aircraft manufacturers are to “make hay while the sun shines.”

**Acquisition Reform and Accountability.** The final point one can make about the potential termination of the F136 pertains to acquisition reform, or “good government.” This committee has recently held multiple hearings on defense acquisition reform, and members have consistently expressed concern about perceived shortcomings in the current acquisition system, or a lack of personal accountability in acquisition decisions. As this committee 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, it may be worth noting that the competition during the “Great Engine War” appears to have 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 PW provide 6 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 6 years of firm-fixed price, or “not-to-exceed” contracts from the first

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<sup>48</sup>Maj. John Nix and Maj. Riley Shelnett. “Behind the Alternate Fighter Engine Competition.” *Aerospace America*. May 1984.

<sup>49</sup> “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.

<sup>50</sup>“Market Overview: Fighter/Attack Aircraft.” *World Military & Civil Aircraft Briefing*. Teal Group Inc. (Fairfax, VA) February 2006.

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, and contractors were not compelled to provide cost projections years into the future.<sup>51</sup>

By requiring GE and PW 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.<sup>52</sup> Further, after competition was introduced, the incumbent (PW) offered “engine improvements to the Air Force earlier than the Air Force had been led to expect without the competition.”<sup>53</sup> 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 reprocur spare parts from sources other than the prime contractors.”<sup>54</sup>

An often cited study on competition during defense procurement – the “Pilling Study” -- notes that “...the benefits of competition do not accrue simply by holding a competition” and “starting up a second source is no guarantee that performance, schedule, or cost problems will be eliminated.”<sup>55</sup> Competition between manufacturers must be effectively managed. It is unclear whether DoD’s leadership today would be able to exploit the JSF Alternate Engine competition as effectively as Air Force leaders orchestrated the Great Engine War in the mid-1980s. It appears clear however, that the very large production run of JSF engines required to make competition between to producers cost effective, is unlikely to be replicated in future aircraft programs.

**Conclusion.** Mr. Chairman, this concludes my remarks on the F136. Thank you for the opportunity to appear before you and discuss this important issue. I look forward to addressing any questions you or the committee may have.

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<sup>51</sup> Telephone interview with Col. James Nelson (Ret.) OpCit..

<sup>52</sup>U.S. Congress, House, Committee on Armed Services, *Air Force Alternative Fighter Engine, Hearings before the Subcommittee on Procurement and Military Nuclear systems*, 98<sup>th</sup> Cong. 2<sup>nd</sup> Sess., March 8, 1984.

<sup>53</sup>Robert W. Drewes. *The Air Force and the Great Engine War*. NDU Press (Washington, DC) 1987.

<sup>54</sup> Prepared Statement of Hon. Thomas Cooper. *Air Force Alternative Fighter Engine, Hearings* OpCit.

<sup>55</sup> Donald L. Pilling. *Competition in Defense Procurement*. Brookings (Washington, DC) 1989.