

# AMERICA'S SELF-DESTROYING AIRPOWER

Becoming Your Own Peer Threat

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## SUMMARY

No military service has currently shown that its leaders can create affordable procurement programs. Every service has, to some extent, mortgaged its future by failing to contain equipment costs, and by trading existing equipment and force elements for developing new systems that may never be procured in the numbers planned.

The end result is an ill-concealed struggle to solve the resulting procurement problems by either raising the defense budget or somehow getting more funding at the expense of other services and programs. The US defense procurement system has effectively become a “liar’s contest” in terms of projected costs, risk, performance, and delivery schedules.

These problems are illustrated in three other Burke Chair reports:

*A Poisoned Chalice?* available at:

[http://www.csis.org/media/isis/pubs/080630\\_fy2009\\_poisoned\\_chalice.pdf](http://www.csis.org/media/isis/pubs/080630_fy2009_poisoned_chalice.pdf)

*Abandon Ships*, available at:

[http://www.csis.org/media/isis/pubs/080822\\_naval\\_equipment\\_acquisition.pdf](http://www.csis.org/media/isis/pubs/080822_naval_equipment_acquisition.pdf).

and *The Future Combat System*, available at:

[http://www.csis.org/media/isis/pubs/090205\\_fcsarmy.pdf](http://www.csis.org/media/isis/pubs/090205_fcsarmy.pdf)

Almost every major aircraft development program is in so much trouble that the replacements are stuck in a morass of procurement and development problems, cost explosions, and rifts within the Department of Defense. Fifth-generation tactical aircraft are affected by significant delays and cost increases.

Some estimates indicate that the F-22 has almost tripled in unit cost. In part because the planned procurement quantity has been reduced from 750 to 183, which has contributed significantly to the increased unit cost. Although industry officials are more optimistic about the much larger program of the F-35 Joint Strike Fighter, it may face a similar fate and not be ready in time to replace aging legacy fighters. This contingency will create a “fighter gap” in the Air Force’s and Navy’s inventories. The strategic capabilities are not less affected by these problems.

A new bomber is planned, but the previous B-2B program escalated in cost by a factor of at least 300 percent, and was reduced to roughly one fifth of its original force goal. Finally, a program to replace the almost 50-year old air refueling tanker is stuck in a political tug of war caused by the Air Force’s mismanagement of the program. Meanwhile, maintenance costs to keep the legacy fleet operational are increasing rapidly.

There now are fewer program alternatives if any key program runs into trouble, failed methods of cost analysis are still in play without adequate cost-risk analysis or use of regression analysis. The pressure to “sell” programs by understating cost and risk have all combined to push air modernization to the crisis point. Current plans for aircraft

modernization are not affordable unless aircraft costs are sharply reduced, deliveries are delayed years longer than planned, or funding shifts to lower cost variants or upgrades of older types. The only alternative is a major increase in real defense spending.

This report examines how these problems affect the tactical, strategic, and enabling capabilities of US air power. It draws on recent government data and news reports to reveal the state of current strategic air power and identify the challenges the administration faces for future force planning and budgeting.

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## INTRODUCTION

No military service currently demonstrates that it has the leadership to create affordable procurement programs. Every service has to some extent mortgaged its future by failing to contain equipment costs, and by trading existing equipment and force elements to develop new systems that it may never be able to procure in the numbers planned. These failures in cost containment have been compounded by the failure to make realistic assessments of technology and production capabilities, and the failure to set reasonable performance specifications and then stop the growth of technological risk and even more demanding performance specifications over time.

### *Rotting the Fish from the Head Down*

No military service today can point to effective leadership in these areas by its Secretary and his staff. Instead, there is an ill-concealed struggle to solve the problems in a failed procurement system by either raising the defense budget or somehow getting more funding at the expense of other services and programs. The US defense procurement system has effectively become a liar's contest in terms of projected costs, risk, performance, and delivery schedules.

There also has been no effective leadership from any element of the Office of the Secretary of Defense. The Secretary, Deputy Secretary and Under Secretary of Defense (Acquisition, Technology and Logistics) have failed to manage from the top. DDR&E, the Comptroller, and PA&E have failed in one of their most basic missions. Documents like the Quadrennial Defense Review – like all of the service strategy documents – have become pointless statements of doctrine, policy, and good intentions that are not supported by workable force plans, procurement plans, program budgets, and measures of effectiveness.

The problem does not lie in defense industry, program managers, mid-level officers and officials, or in the procurement process. It lies in a fundamental failure to take hard decisions and force the overall defense procurement process to become realistic in making easily foreseeable judgments about risk and feasibility, to contain costs, and to create a mix of program objective memorandum and PPB goals that the nation can actually afford. It is a management cliché in the Department of Defense that, “a fish rots from the head down.” Today, this is precisely where the “fish” is rotting.

It is an open contest as to which military service and which aspect of defense procurement is now in the most trouble, but the near term “winners” in this contest seem to be shipbuilding and production of military aircraft. Both have become their own peer threats. These self-inflicted wounds, in terms of force structure and real-world rates of modernization, pose at least as much of a danger as any current foreign enemy. In fact, major questions exist as to whether key aircraft procurement programs will be “force shrinkers” rather than “force multipliers.”

This failure in managing aircraft program execution is already having a major impact on the US Air Force, US Navy, and Marine Corps, and it has reached a crisis point that the current Administration will have to deal with. Industry sources say that delays in production decisions or rescaling programs, as opposed to terminating them, can cost millions of dollars to sustain the engineering. On March 14, 2008, then-Chief of the Air Force General Michael Moseley was quoted in the *National Journal*, asking for an additional \$20 billion per year beyond the administration's requested budget to restock his arsenal.<sup>1</sup> A further article in the same issue, titled "Burned Out," outlined how the 1990s procurement holiday left the services, particularly the Air Force, with rapidly aging fleets that need to be recapitalized.

Yet, almost every major aircraft development program is in trouble and their next generation replacements are stuck in a morass of procurement and development problems, cost explosions, and rifts within the Department of Defense. Studies by the GAO have shown that the cost of key aircraft programs have escalated from 43 percent for the V-22 to 65 percent for the F-22 modernization. These same studies show that the procurement plans for key aircraft have shrunk by as much as 50 percent in the case of the V-22.<sup>2</sup> At the same time, the Air Force and Navy have made major cuts in their number of existing combat aircraft, in part to fund modernization plans they will never have the money to fully implement.

The initial goal of 750 F-22 air dominance fighters has been reduced since the start of the program to a target of 187 aircraft in current plans, including prototypes for testing. The fighter has meanwhile been upgraded with a ground attack capability that added significantly to the cost increase of the system. The modernization program alone has driven the procurement unit cost of the F-22 from \$13 million to \$34 million over the past five years; an increase of 160 percent.<sup>3</sup>

Industry sources state that most of this cost growth stems from adding requirements to the F-22. They also argue that the cost must be put in perspective. Adding ground attack and SEAD (Suppression of Enemy Air Defenses) capabilities to the F-22 allowed taking over missions from the F-16s (SEAD) and the early retirement of the F-117 that cost over \$240 million annually in O&S funding.<sup>4</sup>

The resulting tensions are pitting the services against each other and against the Office of the Secretary of Defense in a competition to determine what capabilities will actually be needed in the future, and who can get the resources to push their program forward.

Meanwhile, two wars are aging the nation's aircraft inventory far more quickly than anyone planned in shaping current air modernization plans, and key combat aircraft like the F-15 are worn to the point where some have disintegrated in mid-air. The strategic posture of the United States and its armed forces has been put at risk with no clear progress towards creating affordable procurement, modernization and force plans and budgets.

## *Today's and Tomorrow's Wars*

The problem is not simply one of forcing the right mix of cost containment, technology and performance specifications, and reasonable delivery schedules on a broken system. These are all key issues, but there are strategic decisions that are critical to making the right choices. The US must shape the coming FYDP to deal with the cost and strains of the wars in Iraq and Afghanistan, and it must establish clear priorities for irregular warfare relative to more conventional threats.

The current focus on the counterinsurgency wars in Afghanistan and Iraq, and Secretary Gate's emphasis on irregular warfare and increased intelligence, surveillance, and reconnaissance (IS&R) capability, either requires major trade-offs within current aircraft and other procurement programs or major increases in the size of the entire defense budget and future year defense program.

Secretary Gates has issued a new "strategy" that emphasizes irregular warfare, and has given the improvement of IS&R capabilities high priority to meet current warfighting needs and serve immediate mission requirements in Iraq and Afghanistan. However, like his predecessor's QDRs, and the strategy of each of the military services, his "strategy" is not yet a strategy at all. It is still a mix of concepts and doctrines which is not defined in a clearly delineated force plan, in a modernization and procurement plan, in any form of program budget and cost analysis, or in any measures of time and effectiveness.

The debate over seeking the most advanced systems possible to deter and defeat any peer threat versus giving priority to irregular warfare and IS&R has not been resolved, and is certain to be revived when a new Administration takes office. The Russian invasion of Georgia alone virtually ensures this, but inter and intra-service infighting alone would have ensured it in any case.

This makes it impossible to know the future plans and priorities for aircraft procurement, and a new Administration will come to office in January 2009. Moreover, even if the Secretary does provide more details on his recommendations for the FY2010 FYDP and relevant details from the FY2010 Program Objective Memorandum (POM), it is unclear that these will represent the result of a serious effort to correct the undercosting and underfunding in past Department of Defense estimates, provide a fully thought out analysis of how the proposed strategy affects air procurement programs, or provide a picture of the future that has the full support of any of the military services.

## *Growing Old Gracelessly*

Meeting urgent needs for US ground forces and the reinforcement of Afghanistan also seems likely to put major additional pressure on the current funding profile for aircraft procurement in spite of the aircraft modernization needs reflected by the steady decline in the inventory of key US combat aircraft shown in **Figure 1**, and in spite of the cuts in



total combat aircraft production and rising age of existing US combat aircraft shown in **Figure 2**.

As these data show, Air Force fighter procurement “crashed” from 228 aircraft in 1986 to zero in 1995, creating both new aging problems and added pressure for modernization.<sup>5</sup> US airpower shrunk steadily in force numbers, although this was partly offset by improvements in technology. If one looks at total US air strength as reported to the IISS, combined US Air Force, Navy, and Marine Corps tactical fighter strength dropped from 5,783 at the end of the Cold War in 1992, to 3,985 in 2000 at the start of the Bush Administration, and 3,542 in 2008. The number of bombers dropped from 276 at the end of the Cold War in 1992, to 208 in 2000, and 180 in 2008. Similar shifts took place in the transport, tanker, and helicopter fleets.<sup>6</sup>

The average age of the remaining inventory has jumped from less than ten years in 1991 to more than 20 years today.<sup>7</sup> As Figure 1 shows, a combination of wartime priorities, delays in the IOC for new aircraft, and massive cost escalation, have doubled the average age of most of today’s in-service aircraft within 10 years. Today’s F-16, the Air Force’s core fighter system, has an average age of 16.7 years. The average age of over 400 Air Force F-15s is 25.5 years. The risks involved are illustrated by the fact that an F-15 broke into pieces in flight on 2 November 2007, due to what proved to be fatigue and wear from 27 years in service.<sup>8</sup>

At the same time, program delays and cost escalation in key programs like the new generation stealth fighter (the F-22 Raptor) meant that a key fighter program intended to replace the Reagan-era fighter did not produce any operational aircraft until late 2005.<sup>9</sup> Now that the aircraft is available, its cost has risen from an original estimate of an average unit procurement cost of \$110 million when procurement started in FY1999 to an estimated average of \$154 million in FY2008 for the flyaway unit cost, and the procurement plan has slipped from 339 aircraft to 173 aircraft over the same time.<sup>10</sup>

Moreover, a serious debate has emerged as to whether its features are needed or justified given its high cost and the priorities for other defense needs. The unit cost of the F-22 has also limited the Air Force to 20 aircraft per year. Even if the Department of Defense funded the program at the current rate, a linear extrapolation suggests that it would take more than 26 years to replace over 400 F-15s. However, any 1:1 comparison is debatable. Industry sources claim that two squadrons of F-15s (48 aircraft) could be retired for each Lot of 20 F-22 aircraft. According to their calculations, the procurement of F-22 Lots 10-12 could replace the entire fleet of F-15 C/Ds in as little as 5-6 years.<sup>11</sup>

The growing burden of the maintenance and service-life extension of legacy fighters is putting increased pressure both the force and defense budgets. Major General Paul Selva, director of strategic planning for the Air Force, has warned that “We’ve operated most of the airplanes we’re flying beyond their originally designed life span.”<sup>12</sup> As a result, the Air Force’s maintenance budget increases while fleet readiness still decreases.

The budget problem is not simply one of paying for new aircraft. It includes dealing with the maintenance and upgrade costs imposed by programs delays. It includes the budget pressures imposed by added investment in IS&R assets, and it includes the “reset” costs to replace lost aircraft and deal with accelerated wear coming out of the Afghan and Iraq Wars. This is certain to have a major additional funding impact on the Air Force’s recapitalization demands, as well as those of the Navy and Marine Corps, which is not reflected in any current budget estimate.

Another Air Force commander has noted that the cost of an F-15 flying hour has doubled within the last ten years, and that “In fact, the cost per flight hour has climbed for every one of the 14 major aircraft types in continuous service since the 1980s (a trend aggravated by rising oil prices). All 14 have lower readiness rates than they did in 1991.”<sup>13</sup>

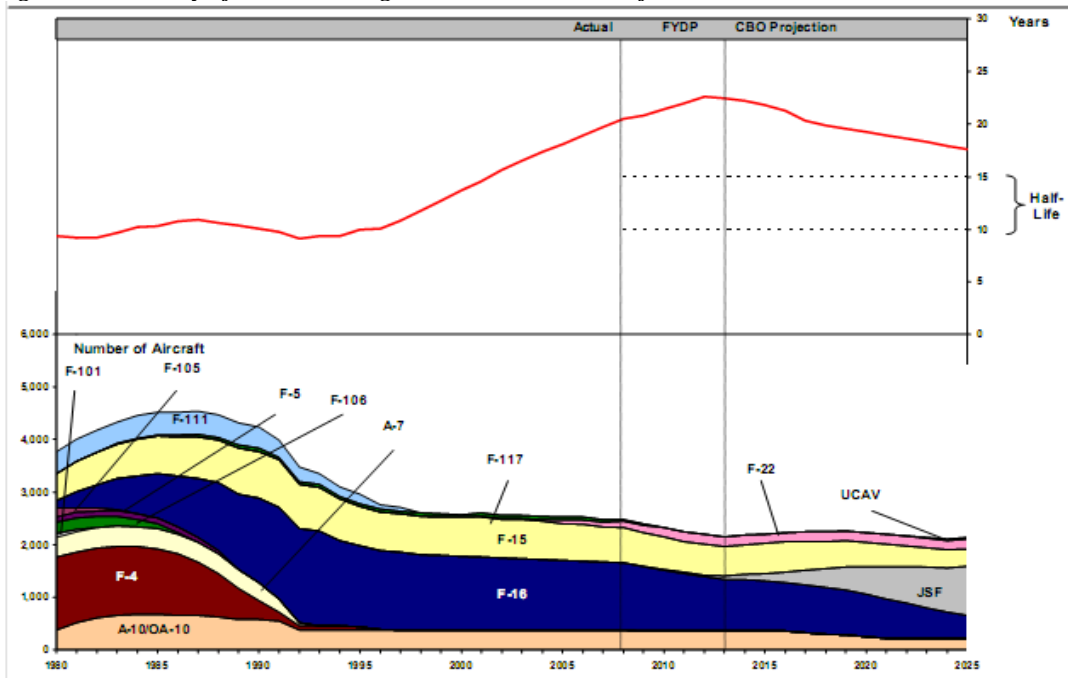
The F-15, however, is only one part of the problem. The average age of the Air Force’s F-16 is 16.7 years.<sup>14</sup> The average age of its B-52 bombers is 46.6 years, and the average age of its KC-135 air refueling tanker fleet averages 46 to 48 years, depending on the model. The tankers date back in President Kennedy’s military buildup and the development and design period of the Eisenhower era. “The tankers are a disaster waiting to happen, with 90 percent of the 600-plane fleet consisting of Eisenhower-era aircraft that will reach an average age of 50 years in this decade,” according to a leading expert on defense procurement.<sup>15</sup>

The Air Force says it has a 40-year recapitalization plan for the tanker fleet but there is no current way to predict how and when it will be executed.<sup>16</sup> The scandal over the leasing program, and revoking the award of a follow-on competitive contract to build such planes, has been followed by further disputes that led the Office of the Secretary of Defense to cancel a new bidding effort and introduce a cooling off period.<sup>17</sup> According to the Air Force Chief of Staff, General Norton Schwartz, the awarding of a new contract could take from eight months to four years.<sup>18</sup>

The 2008 National Defense Authorization Act only allows the retirement of the current tanker aircraft upon award of a new tanker deal. This means a delay of four more years will significantly increase the maintenance cost for the current tanker fleet and decrease its readiness.

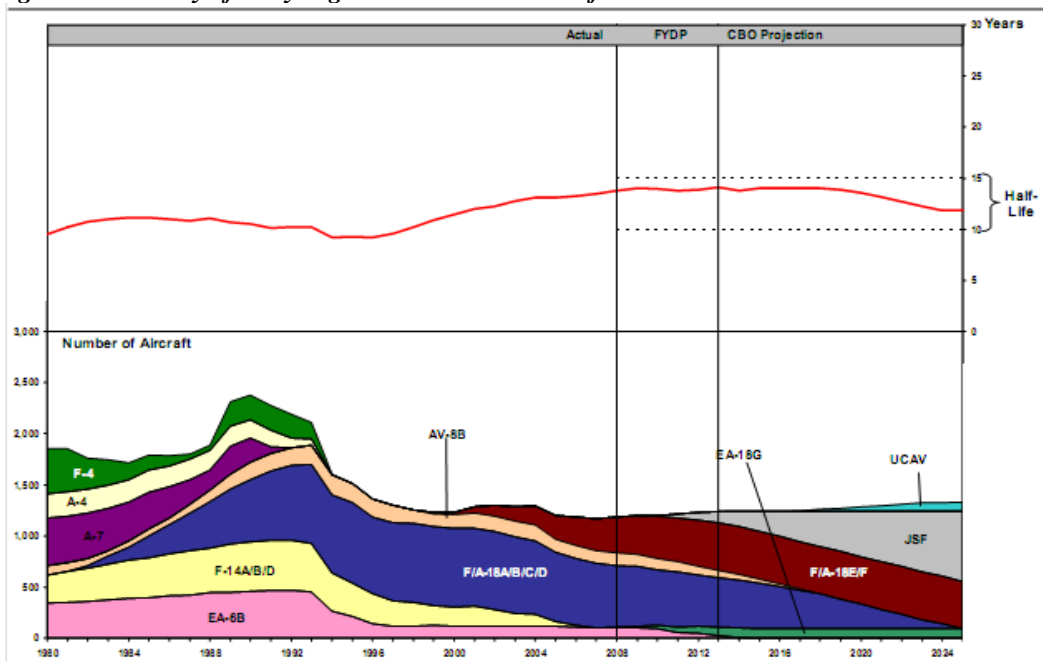
**Figure 1: Rising Age, Declining Inventory: The Downward Trend in American Airpower**

*Age and Inventory of Air Force Fighter and Attack Aircraft*



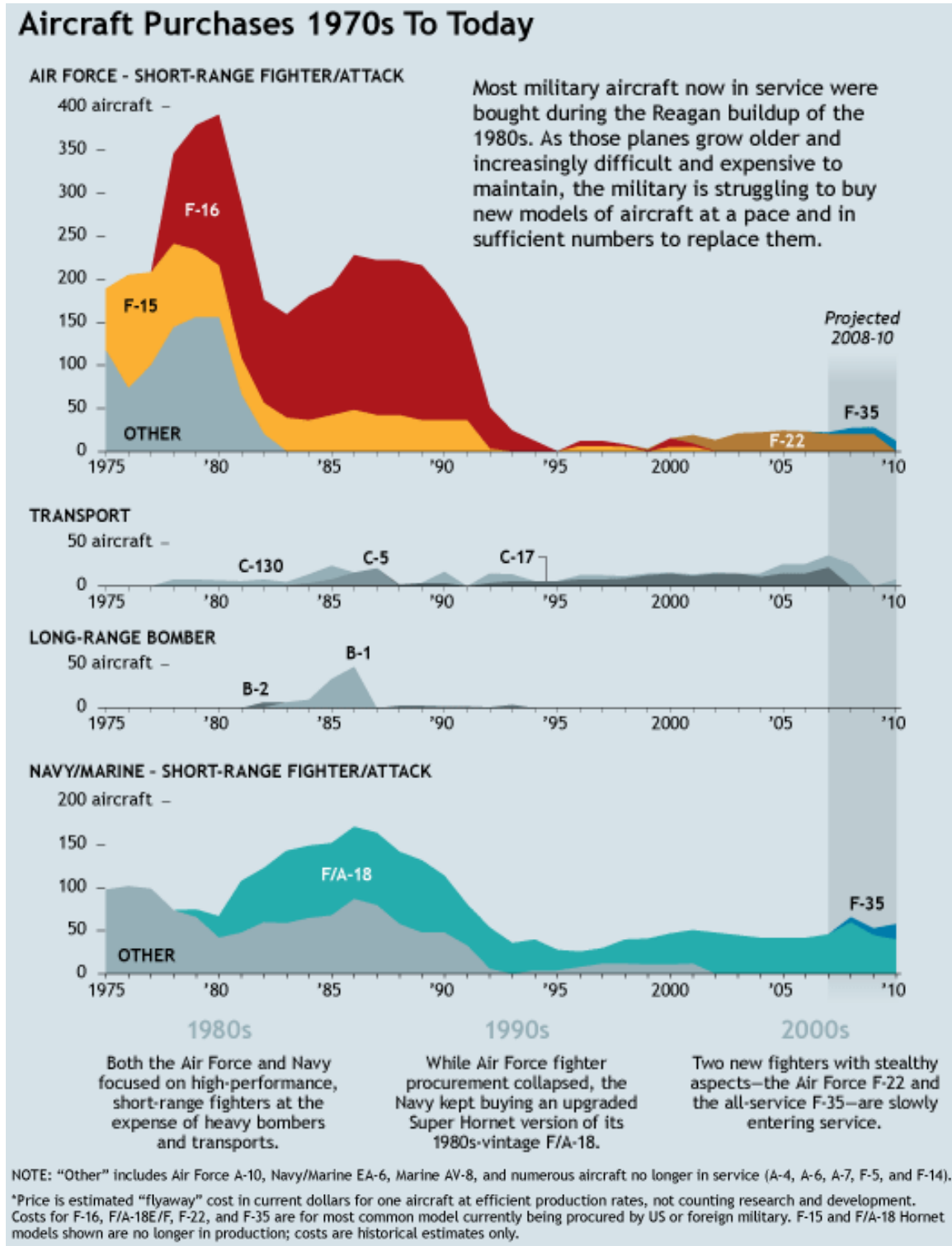
Source: CBO, *The Long-Term Implications of Current Defense Plans*, March 2008, p. 28.

*Age and Inventory of Navy Fighter and Attack Aircraft*



Source: CBO, *The Long-Term Implications of Current Defense Plans*, March 2008, p. 27.

**Figure 2: Aging Aircraft**



Source: National Journal, *The Bills Come Due*, 14 March 2008, cover story.

## THE TRENDS IN PROCUREMENT COST AND THE FY2009 BUDGET REQUEST

The US already faces a bill for aircraft modernization that will be unaffordable unless aircraft costs are sharply reduced, deliveries are delayed years longer than planned, or funding shifts to lower cost variants or upgrades of older types. The only alternative is a major increase in real defense spending.

### *The Longer Term Trend*

The longer term trend in combat aircraft procurement spending is shown in **Figure 3**, which draws on analysis done by the CBO in both current and constant dollars. This trends analysis only covers tactical aircraft, and the CBO made extremely conservative estimates of future cost, given the GAO's analysis of a long history of systematic undercosting and underbudgeting by every military service in estimating its aircraft procurement spending for future years.

Both Air Force and Navy rely heavily on one program -- the Joint Strike Fighter or F-35 - - to modernize their tactical fighter fleets. Procurement of the Joint Strike Fighter will only reach a steady state of roughly 50 aircraft per year for the Navy and 80 aircraft per year for the Air Force in FY2014 and 2015, respectively, according to CBO projections. By that time, all other fighter procurement programs for both services will be phased out. The purchase of the JSF will be critical to keeping the average age of Navy fighters within the targeted half-life span of 10 to 15 years over the projection period of 2008-2025. The Air Force's average fighter age will only decrease after a peak of 22 years in 2012. The JSF purchases will be insufficient to bring the average age below the upper limit of the targeted half-life span of 15 years by 2025.

The CBO estimates Navy and Marine fighter and attack aircraft funding to average about \$5 billion a year, excluding cost risk, in the 2008-2025 period. This estimate is based on the assumption that JSF acquisition costs will remain stable and the procurement program will meet the schedule. However, the GAO stated in a March 2008 assessment that the "estimated acquisition costs [of the JSF] have increased by almost \$55 billion (then-year dollars)" since the program rebaseline in FY2004.<sup>19</sup> Following the GAO's assessment, other factors may also distort the CBO projections significantly since there are "knowledge gaps that expose the program to significant risk."<sup>20</sup> These include the fact that the F-35 allows almost no room for growth in weight and seems to have potential power problems.

Industry officials challenge the CBO's assessments, and claim that there are currently no known technical showstoppers in the F-35 program. While they acknowledge that there is always some residual risk with development programs, they argue that the program's investment in the largest and most comprehensive ground-based and airborne laboratory system ever applied to a fighter aircraft is retiring risks rapidly. They mention further achievements in reducing risks such as over 70 test flights and the integration of all sensors in surrogate aircraft. Finally, they state that the F-35 allows for three percent

weight growth between the Critical Design Review and Initial Operational Capability and that all variants are within weight growth specifications.<sup>21</sup>

As is discussed in more detail later in this report, the F-35 program is likely to put the Air Force's procurement budget under even greater pressure in the future. The total investment will increase from \$61 billion in FY2008 to \$63 billion a year in the FYDP period between 2008 and 2013. For the 2014-2025 projection period CBO estimates that the average annual investment would reach \$68 billion. However, investment funding could be as high as \$74 billion a year between 2014 and 2025, if the historical cost growth in the service's procurement budget is taken into account, the CBO estimates.<sup>22</sup>

The end of the JSF program procurement schedule has already been extended by seven years from 2027 to 2034 and annual procurement rates have been steadily reduced, and further delays seem likely due to technical difficulties in the development, further delays are not unlikely. The GAO's assessment states that "[t]he first test aircraft completed needed 35 percent more labor hours than planned and follow-on aircraft are not meeting a revised schedule put in place in 2007."<sup>23</sup> A general lack of testing and evaluation, and adequate numbers of test aircraft may further incur significant cost increases due to problems that may require design and production changes, the GAO comments.

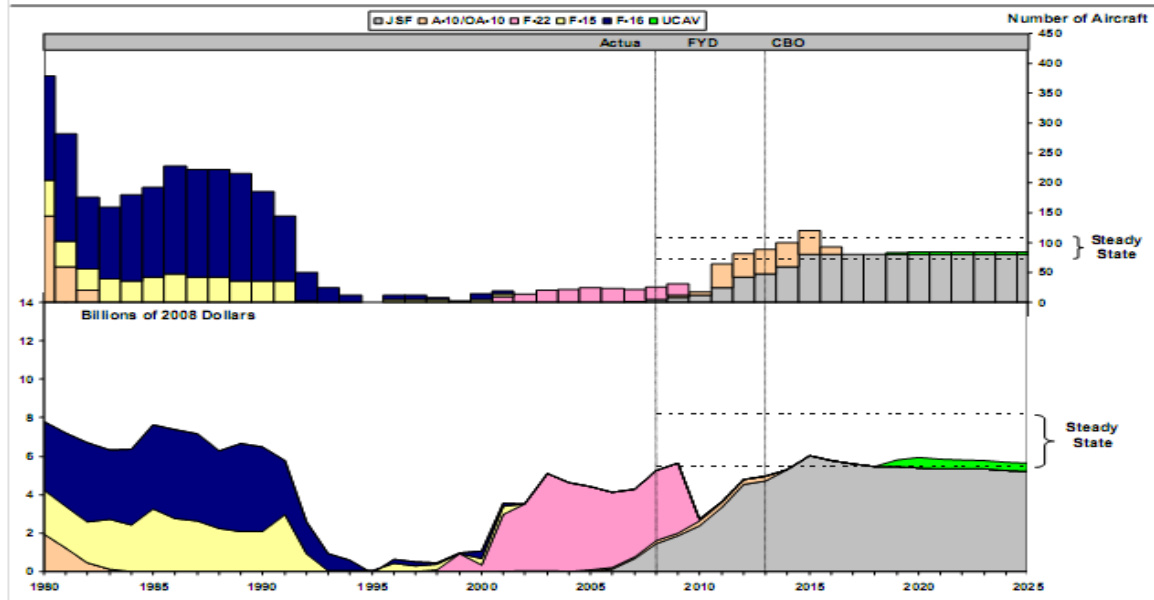
Industry experts reply that the GAO's call for increased testing prior to production and procurement decisions would cost billions of dollars and significantly delay capability to the warfighter. Moreover, they argue that there are in fact sufficient test aircraft and the most rigorous test plan of any fighter ever developed is in place. They add that the F-35 program has the same number of test hours as the AV-8B, F/A-18A/B, and the F-16A/B flight test programs combined. Finally, the industry is confident that their laboratory tests and flight tests on surrogate aircraft greatly mitigate risks.<sup>24</sup>

Industry experts also state that a speedy delivery of the F-35 carrier variant could also mitigate significant operational risk for the Navy, which is facing a 'strike fighter-gap' between 2016 and 2025. This gap will widen if JSF production will not be able to meet the schedule. Meanwhile the Navy is exploring the option of buying "from 50 to 282 more F-18s, and either speeding or delaying JSF."<sup>25</sup> Some Navy leaders doubt that upgrading older F-18s would make financial sense. What is certain is that reducing the numbers of JSF purchases will further drive the program unit costs up for future purchases and for purchases by the other services.

The CBO's estimates of steady fighter aircraft procurement spending of \$5-6 billion a year are based on a best case scenario that defies all recent cost and schedule developments. Such budgets are unlikely to buy the numbers required in current plans. In addition, fighter aircraft budgets face heavy competition from other programs, such as Secretary Gates' priorities of ISR capabilities and a build-up of ground forces. The FY2009 budget request exemplifies this competition for funding.

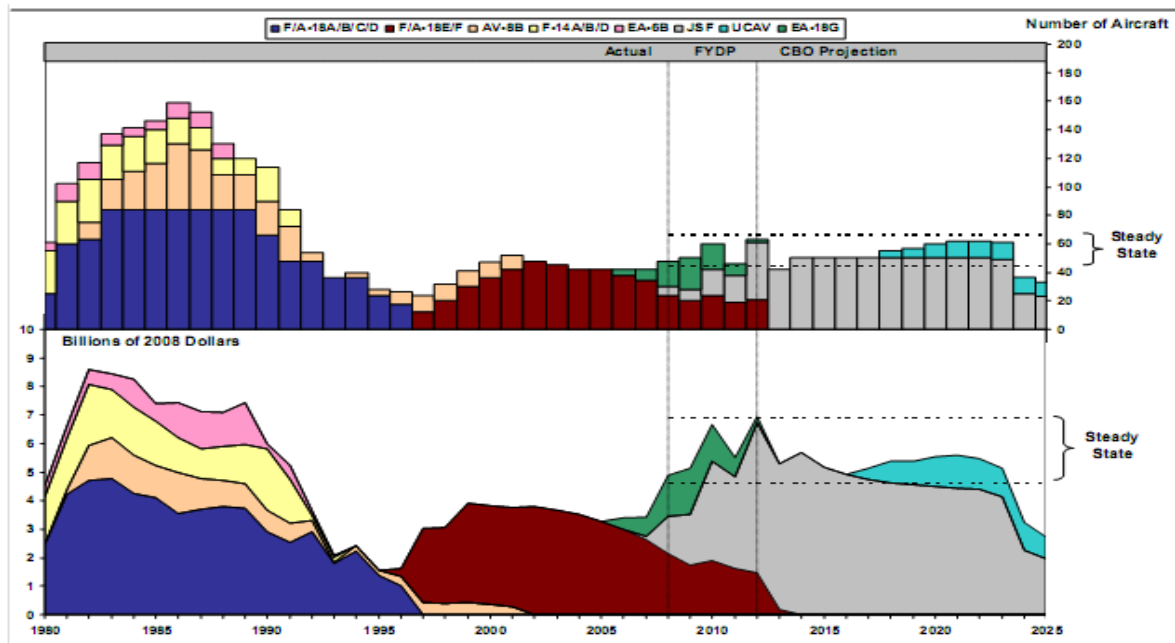
**Figure 3: Inadequate Procurement Spending and Inadequate Realism in Projecting Future Costs**

*Underfunding of Air Force Tactical Air Programs Even Assuming No Continued Escalation of Procurement Costs*



Source: CBO, *The Long-Term Implications of Current Defense Plans*, March 2008, p. 27.

*Underfunding of Navy/USMC Tactical Air Programs Even Assuming No Continued Escalation of Procurement Costs*



Source: CBO, *The Long-Term Implications of Current Defense Plans*, March 2008, p. 20.

## ***The FY2009 Budget Request***

The Fiscal Year (FY) 2009 budget request reflects the latest attempt to transform the United States armed forces. Secretary Gates' focus on fighting today's wars and his vision of predominantly counterinsurgency-type wars in the future have started to shift the budgetary focus away from air-dominance jet fighters and other tactical combat systems to unmanned aerial vehicles (UAVs) and other network, surveillance and reconnaissance capabilities. Resistance from the Air Force has not fallen silent, even after the ouster of the Air Force's civilian and military top leadership.

The FY2009 Defense base budget request includes \$45.6 billion for improving joint air capabilities, an increase of about \$4.9 billion over the FY2008 enacted budget.<sup>26</sup> **Figure 4** lists the priorities for combat and tactical systems.

Most of the increases are absorbed by higher numbers in F-35 procurement, although the current rate has not reached steady production. Another funding priority is the V-22, which is reaching steady procurement at 30 aircraft a year in FY2009. At the same time, war needs are driving budget priorities with more funding going to tactical airlift capabilities, such as the CH-47 Chinook that are needed in the wars in Iraq and Afghanistan.

Another large portion of funding for combat and tactical systems is absorbed by the F-22. This is due to its high unit costs at a minimum procurement rate of 20 aircraft to keep the program alive. Plans call for a phasing out of the F-22 in FY2009, but the decision to shut down the production line has been deferred in 2008 to the current administration (see section on F-22).

**Figure 4: FY2009 Joint Air Capabilities – Combat and Tactical Systems (US\$ Millions)**

|   | FY 2007  |      | FY 2008  |      | FY 2009  |      |
|---|----------|------|----------|------|----------|------|
|   | Quantity | Cost | Quantity | Cost | Quantity | Cost |
| F-35 Joint Strike Fighter <sup>a</sup>    | 2        | 478  | 12       | 2394 | 16       | 3276 |
| F-22A Raptor                              | 20       | 2716 | 20       | 3131 | 20       | 3054 |
| V-22 Osprey                               | 14       | 1364 | 21       | 1747 | 30       | 2133 |
| F/A-18E/F Hornet                          | 37       | 2685 | 24       | 2028 | 23       | 1869 |
| E/A-18G Growler                           | 9        | 696  | 18       | 1258 | 22       | 1605 |
| CH-47 Chinook                             |          |      | 6        | 157  | 16       | 444  |
| VH-71 Helicopter <sup>b</sup>             |          | 614  |          | 225  |          | 1048 |
| KC-X Aerial Refueling Tanker <sup>c</sup> |          |      |          |      |          | 62   |
| MQ-1 Predator <sup>d</sup>                | 60       | 754  | 24       | 323  | 38       | 418  |
| MQ-9 Reaper                               |          |      | 4        | 58   | 9        | 161  |

a. Includes 2 F-35 for the Air Force in 2007, 6 each for the Air Force and the Navy in 2008, and 8 each for the Air Force and the Navy in 2009.

b. Navy RDT&E

c. \$62 million in advance procurement.



d. Includes RDT&E of \$78 million in 2007, \$47 million RDT&E in 2008, and \$39 million RDT&E in 2009.

**Source: Undersecretary of Defense (Comptroller), *National Defense Budget Estimates for the FY 2009 Budget (Green Book)*, March 2008.**

## TACTICAL AIRCRAFT PROGRAMS

The problems that have emerged from years of failure to contain costs, manage technology risk and performance specifications, and set realistic procurement and force goals become much clearer from an examination of key aircraft programs.

### *F-22 Raptor: The Only Serious Peer Threat to the USAF is the USAF?*

The F-22 Raptor is the Air Force's most advanced fighter aircraft. Its requirement and design features originated during the Cold War and it was designed for an air dominance role when the first two prototypes were being developed in 1986. It now features the latest in stealth technology and advanced engines and avionics, and can deliver precision attack weapons as well as perform the air-to-air combat mission. Although it has had some development problems, its performance seems to be outstanding. The key issues are cost and whether its features are worth that cost, given the overall priorities and mission needs of the Department of Defense.

The F-22 is still supposed to relieve the aging fleet of F-15s, the average age of which is 26 years. The entire F-15 fleet had to be grounded in 2007, following the aforementioned incident where an aircraft disintegrated in flight.<sup>27</sup> Some estimates indicate that the F-22 Raptor's manufacturing cost, however, has risen to \$122-\$181 million apiece, excluding R&D costs. Industry experts state, however, that the variations in cost are mostly due to different cost calculations, such as Program Acquisition Unit Cost (PAUC), Average Unit Flyaway Cost (AUFC), or Unit Recurring Flyaway Cost (URFC), which generally apply different ways of distributing non-recurring development costs on units. Industry sources mention an average unit recurring flyaway cost of \$140 million for the F-22.<sup>28</sup>

Further cost escalation seems likely, as US combat aircraft have a long and painful history of costly post-IOC design fixes and mission changes to deal with initial design and production programs. As mentioned earlier, however, additional requirements and delays could be a major driver in such cost increases. Industry officials also claim that the recurring cost for the F-22 unit has come down 35 percent since Lot 1.<sup>29</sup> The Air Force's procurement plan of 20 aircraft per year will not allow the 441 F-15C/Ds to retire by the middle of the next decade. The Air Force plans to maintain a fleet of 177 F-15Es through 2025. By that time, some of the fighter jets will be 40-45 years old. F-15E air-to-ground aircraft will eventually be replaced by F-35s.

### *Failed Cost Containment Means Program Reductions*

The planned acquisition number of F-22s has been to be steadily reduced over time. Various pressures have forced the Air Force to cut back on the planned number of F-22s. The stealthy fighter was viewed as a necessary response to the development of advanced Soviet combat aircraft in the 1990s. The reduced threat in Europe led to a Bottom-Up

Review by DoD in 1993. The initial goal of 750 aircraft was then cut to 442 (including four pre-production versions).

The Quadrennial Defense Review of 1997 further reduced the planned purchase to 339 aircraft, and reduced the maximum annual production rate from 48 to 36 aircraft.<sup>30</sup> The QDR's recommendation to reduce total production was based on budgetary constraints rather than a strategic reassessment. A lower rate of production was also judged more affordable, but no recommendation was made to a specific numerical production target.<sup>31</sup>

### *The Post 9/11 Case for the F-22?*

When the present Bush administration came to office, it shifted priorities from replacing the aging air dominance F-15 fighter with an aircraft that could dominate any peer threat in air-to-air combat to funding the global war against terrorists. By that time, air-to-ground attack capability was added to the fighter, adding an 'A' to the aircraft's designation F/A-22 and adjusting to the post-Cold War requirements for the Air Force. At the same time, the planned procurement goal was reduced to 276 aircraft.<sup>32</sup> This led the Subcommittee on National Security, Emerging Threats, and International Relations of the House Committee on Government Reform asked the DoD to provide a new business case for the F-22, explaining the planned number to be procured. Clearly, at 276 aircraft, the program was unfit to replace the F-15 fleet.

By then, the Bush administration's business case for the F-22 had been reduced to a "buy to budget" concept.<sup>33</sup> Strategic considerations and a solid doctrinal, mission, and force plan rationale for the F-22 system became more a matter of rhetoric than substance. No clear defense was made of how many F-22s are really needed to fill the Air Force's requirements and no clear strategy has been announced to explain its role in substituting for the aging F-15 fleet.

While more may have been done at a classified level, the shift to a focus on a global war on terrorism, and away from the classic air-superiority mission, left the F-22 program in a kind of strategic limbo. The fighter's purpose came to be described largely in technical terms rather as part of a comprehensive strategy for the Air Force, to an integrated force plan, or a comprehensive air modernization budget. The resulting procurement numbers only showed how many F-22 are affordable. Furthermore, investments on expanding the F-22's air-to-ground capability have not been clearly justified and the strategic purpose of the system was left uncertain in a critical stealth mission area.

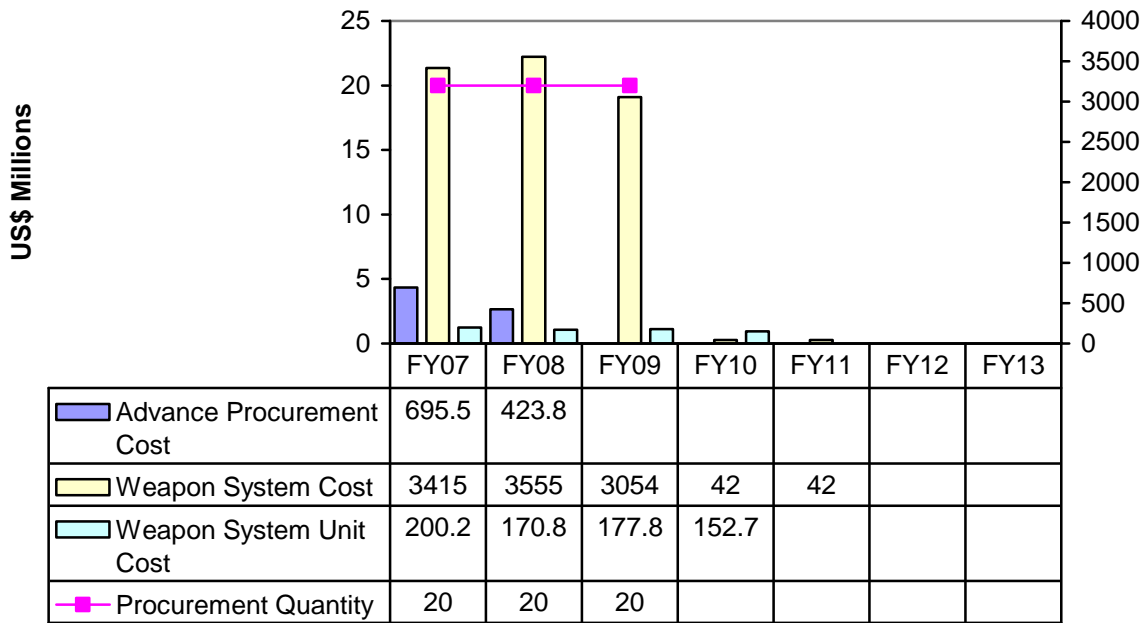
The revised business plan recommended by the GAO in 2003 was never provided. Instead, the Office of the Secretary of Defense (OSD) has restructured the program two more times: in 2004 and 2005. A reduction down to 179 aircraft in December 2004 Program Budget Decision (PBD) was intended to free resources of over \$10 billion for other purposes. In the same effort, the procurement was set to be terminated on 2008. Only a year later, in December of 2005, OSD added another \$1 billion to extend the

production of the F-22 by two years. The stated reason behind this decision was to keep the production line open in case the JSF experienced delays or problems.<sup>34</sup>

This has led to growing tension between the DoD and the Air Force. DoD supported plans and budgets for a total number of 183 F-22s, including 6 Production Representative Test (PRTV) II aircraft, on its FY2009 budget request.<sup>35</sup> However, the Air Force -- and most notably former Chief of Staff General Michael Moseley and Secretary Michael Wynne -- repeatedly called for a fleet of 381 F-22 necessary to equip 10 squadrons with the 5<sup>th</sup> generation fighter.

This led to a clash with Secretary of Defense Robert Gates, who stated in February 2008 that the “F-22 had no role in the war on terror”.<sup>36</sup> Gates consistently defended the 187 aircraft plan, but deferred a decision to close the production line to this administration when he still worked for the Bush administration. He said that he decided “to allocate sufficient money to continue buying a few more models of the airplane through the Bush administration and into the next – keeping the factory open so the next president could decide the proper number and kind of new fighters.”<sup>37</sup> At this point in time, the production plan is the one shown in **Figure 3**.

**Figure 3: Phasing Out F-22 Production**



Source: United States Air Force, Fiscal Year 2009 Budget Estimates, February 2008, Exhibit P-40, p. 1-13.

***Keeping the F-22 Alive and Affordable or Giving It a  
Mercy Killing?***

Even though there has been no firm decision to discontinue the F-22 program, the manufacturer will currently shut down the line when the three-year procurement contract runs out in 2010. The supplier chain will reportedly begin to atrophy, if there are no more additional funds by the end of October 2008, according to industry sources.<sup>38</sup> Advance funding is necessary to manufacture certain key components, including bulk heads, horizontal stabilizers, radar, and communications and navigational equipment, which take much longer to produce. Shutting the lines down and later reopening them would raise the program cost significantly.

A Rand Corp. study conducted for the Air Force concluded that the procurement of an additional 75 aircraft could cost up to \$19 billion (\$253 million each) if the program was discontinued and later reopened. The same number of aircraft could be procured for only \$13.7 billion (\$183 million each) if the current production rate of 20 aircraft were continued through 2012 and then reduced to 15 per year, starting 2013.<sup>39</sup>

As is pointed out in a GAO study, recent decisions to cut the number of F-22s to be procured “created a mismatch between the Air Force’s stated requirements and what OSD considers an affordable quantity of F-22As.”<sup>40</sup> Loren Thompson from the Lexington Institute notes that the “Pentagon doesn’t have a coherent plan for how it will sustain global air dominance over the next 30 years without a sufficient number of F-22s, because it has convinced itself that unconventional warfare is the wave of the future.”<sup>41</sup> Making decisions by default is not leadership, it is an abdication of responsibility.

Recent statements in Congress have failed to address the issues affecting national security and the future of the Air Force, but they have defended the program on the narrow ground of constituent interest. Several Members have warned of “serious disruptions, resulting in layoffs,” due to the lack of additional funding for the F-22 program.<sup>42</sup>

Senators Cornyn (R-Texas) and Inhofe (R-Oklahoma) urged the Senate Armed Services Committee Chairman to adopt a House recommendation adding \$523 million to the FY2009 National Defense Authorization Act for the advance purchase of parts for 20 additional F-22s in 2010. A Senate version of the bill set aside \$497 million dollars to the current administration’s discretion. But a decision was needed by November, Cronyn and Inhofe said to prevent a gap in deliveries. Without those funds, the supply chain would erode, which would affect 8,100 jobs in Texas attached to the F-22 production.<sup>43</sup> Industry sources expect a total of 95,000 jobs to be affected directly or indirectly across the country.<sup>44</sup>

The problem in terms of military capability, industrial base, and technology is serious. The jobs argument, however, is ultimately specious from any aspect of national interest. The federal budget will not be cut, and roughly the same number of jobs will be created or maintained somewhere else.

### *Cost Escalation*

Successive Secretaries of the Air Force, Air Force Chiefs of Staff, and the senior officials in OSD who are supposed to be their managers and superiors have failed to come to grips with these problems and make hard decisions. Development and production costs, including the modernization, for the F-22 have skyrocketed since the start of the program. The concurrence of various doctrinal, budgetary and procedural factors has contributed to this cost increase.

As mentioned above, the threat perception has changed unfavorably for the concept of an air superiority fighter since the end of the Cold War. Critics have spoken out against such a sophisticated aircraft and questioned its affordability, and DoD has put an emphasis on counterinsurgency, stability operations and other low-intensity missions. It is impossible to predict, whether air dominance capabilities, such as that of the F-22, will be needed as much in the future as they were in the Cold War. A thorough discussion about aircraft requirements must precede the discussion of its costs and cannot be excluded from a decision about the F-22's fate.

The GAO holds DoD's procurement process responsible for at least some unit cost increases. According to the agency's letter to Representative Bill Young, dated 20 June 2006, "unit procurement costs increase[d] from \$166 million per aircraft to \$183 million per aircraft for the proposed multiyear contract,"<sup>45</sup> from the President's FY2006 budget plans to buy 56 aircraft in two lots to the FY2007 plans to buy 60 aircraft in a multiyear procurement contract.

The letter also criticized the Pentagon's approach to fund the multiyear procurement plan in increments for economic order quantity, advanced buy, subsystem, and final assembly. The GAO refers to the FY2005 and 2006 Department of Defense Appropriations Acts and to the FY2003 National Defense Authorization Act when it states that "[i]ncremental funding for multiyear procurement is neither permitted by the annual DOD appropriations act, nor the multiyear authorizing statute which requires that funds only be obligated under a multiyear contract 'for procurement of a complete and usable end item.'"<sup>46</sup>

As is the case with virtually every other aircraft under development (and most other major weapons systems and procurements), no coherent effort has been made to contain costs, or to procure a cheaper and less sophisticated version of the aircraft. Each cut back in production has been heavily influenced by the cost impact of understated technology risks, increases in performance requirements, and cost growth which is more the product of using cost estimation methods with a long record of deceptive undercosting. It was always possible to see these problems coming, generally years in advance.

Industry sources attribute most of the cost growth to the incremental program cuts. They state that cutting the number of planned aircraft in half doubled the unit cost. Development costs will be divided onto half the number of aircraft and economies of

scale are lost with 20 aircraft per year, as opposed to the 32 aircraft per year optimal production rate.

This long history of conducting a liar's contest, rather than managing a program, led the Congress to mandate a budget cap to contain costs. This led to further cuts in the planned acquisition of the system and the DoD's buy-to-budget approach. Furthermore, Congress has opposed the sale of the aircraft to foreign customers, concerned about the technology proliferation.<sup>47</sup> The resulting cuts in the number of planned procurement of the system have driven up the unit cost significantly.

Costs for the F-22 modernization have exploded due to funding decreases, schedule slips, and changes in requirements and work content in each one of the planned three development increments. According to a GAO survey, the procurement costs for the modernization program have more than tripled since development started in 2003. The program unit cost has almost tripled in the same time, while the planned procurement quantity of the system has decreased by 37 percent.<sup>48</sup>

Industry sources emphasize the correlation between the reduced quantities and the increasing unit cost and point to the inconsequential decisions by OSD that led to significant inefficiencies. In 2004, Congress and OSD cut over \$500 million out of the modernization program only to add \$2 billion in 2008 when much of the upgrades had to be included in the field instead of in the production line.

Unforeseen technical problems could incur further expenses, according to the CRS. At this late stage of development, technical fixes and retrofitting would be particularly costly and cause further delays. The CRS highlights the following areas of concern:<sup>49</sup>

- In April 2004 it was reported that Air Force testers had encountered unexpected overheating in key Raptor components. Software modifications were required to ameliorate the problem, but a long term solution was not immediately apparent.
- During flight testing on September 28, 2004, an F-22A experienced more "G" forces than designed. The aircraft was grounded, and it was subsequently reported that the problem was caused by flight control software problems.
- On December 20, 2004, a Raptor crashed and was destroyed at Nellis AFB.
- In December 2005 it was discovered that 91 F-22s suffered a "heat treatment anomaly" in a titanium fuselage structure. This figure was later revised to 101 aircraft.
- In May 2006 it was reported that the F-22 program would require \$100 million to carry out a structural retrofit program for 41 of the existing aircraft, but Air Force officials state that no remedial action is required. However, these faulty titanium forgings will require increased inspections during the Raptor's 8,000 hour lifetimes to avoid catastrophic failures.

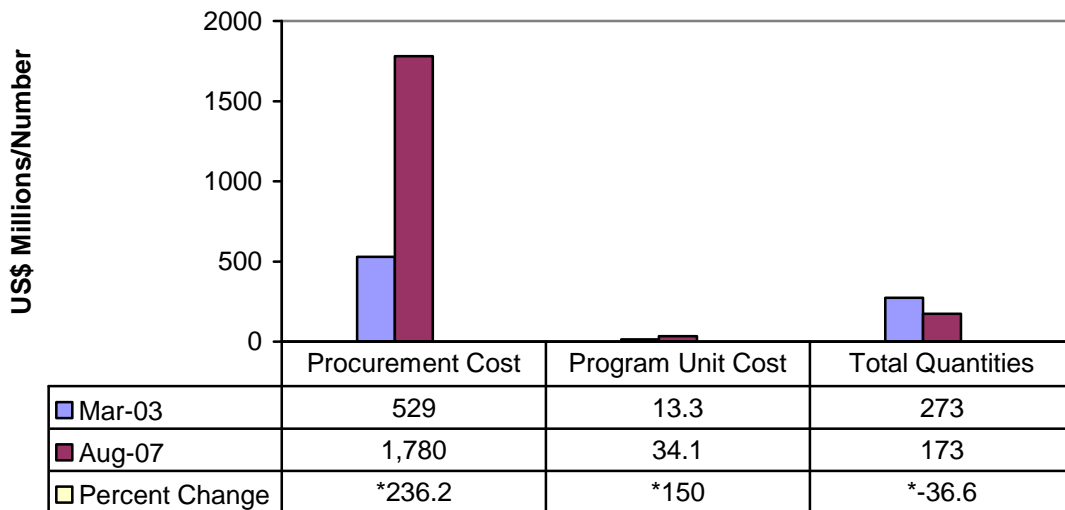
The CRS's concerns provide an unbalanced list, according to industry officials, who emphasize the number of successes since IOC. The concerns raised by the CRS were mostly due to requirement changes or human failures, industry sources say. They reassure that all of these concerns occurred during the Engineering, Manufacturing and Development (EMD) phase and that all of them were handled very efficiently and none of them had been an issue on the operational fleet.

***Looking at the Future***

It is all too easy to speculate about the proper future of the F-22 from the outside. The problem is that there are so few data that provide a proper basis for decisionmaking. The Air Force has no meaningful public strategy; it has no clear net assessments and justified mission requirements. It has no force plan, modernization plan, and procurement plan, and no program budget. A critical Air Force procurement is left in a limbo of slogans rather than explained in the kind of terms that allow clear analysis of the justification of the F-22. On the other hand, killing the program because of its cost is not a more meaningful answer, nor are vague statements about competing strategic priorities. This is particularly true without a clear plan for other forms of fleet modernization.

Whether better planning exists at a classified level is something left for the new Administration to examine, along with so many other planning, programming, and procurement issues. This seems to be one more case where senior leaders first hid the lack of key decisions in a blizzard of snowflakes and will leave office with the decisions hidden in a fog.

**Figure 4: F-22A Modernization Program Cost Explosion**



Source: GAO, Defense Acquisitions – Assessment of Selected Weapon Programs, March 2008, p. 85.

***F-35 Joint Strike Fighter: Aching Jointness***

The Joint Strike Fighter Program is the largest and most important air procurement program now underway. It is intended to produce a family of new-generation tactical aircraft to replace an aging fleet of legacy aircraft and perform a wide range of missions. This would make the Joint Strike Fighter the backbone of the future U.S. military tactical air fleet. Three variants of the fighter aircraft are to be produced to serve the Navy, the



Marine Corps, and the Air Force. In addition, eight international partners have pledged funds – Australia, Denmark, Italy, Netherlands, Norway, Canada, Turkey, and the United Kingdom.<sup>50</sup>

For the Air Force, the F-35 Joint Strike Fighter is supposed to be significantly cheaper than the F-22, and to replace the Air Force's 1,200 F-16s by 2030 – if it is on schedule.<sup>51</sup> This makes it as critical, or more critical, to the future of the Air Force than the F-22. A Carrier version (CV) has been designed for the Navy and a Short Takeoff/Vertical Landing version for the Marine Corps. The Navy procured its first six aircraft in FY2008 and will increase acquisition to 40 and 42 in FY2012 and FY2013, respectively. The Navy's plans include a total amount of 680 aircraft in their FY2009 plans. According to the CBO, the Navy will spend an average of \$5 billion per year between 2014 and 2025 to purchase an average of 50 JSF aircraft per year during the same time.<sup>52</sup> The JSF program will allow retiring the legacy F/A-18A/B/C/Ds. By the time the last Navy JSF will be purchased in 2025, the current F/A-18E/Fs will be reaching retirement age at around 30 years.

The program emerged from the Joint Advance Strike Technology (JAST) program, which resulted from the Clinton administration's Bottom-Up Review of U.S. defense policy and programs in 1993. In late 1996, the CBO estimated the total program acquisition costs at \$219 billion in FY1997 dollars, of which \$22 billion would be spent on research and development.<sup>53</sup>

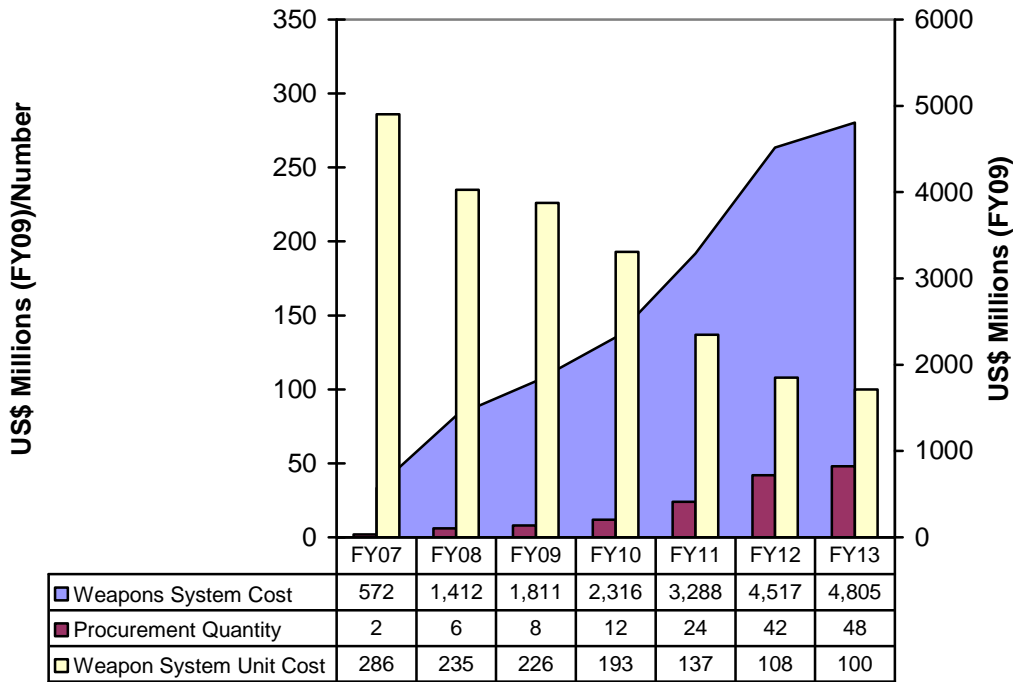
### *The Air Force Program: Another Step in the Quest for Unaffordability?*

**Figure 5** shows the Air Force's procurement plans for the F-35 through FY2013. It is clear that the F-35 has become one of the most expensive single procurement programs in the history of the Department of Defense.<sup>54</sup> In its FY2009 budget estimates, the Air Force projects an average weapon system unit cost for the F-35 JSF until FY2013 that is half that of the F-22's, at \$90 million.<sup>55</sup> As has been discussed earlier, the unit cost of the F-22, at an estimated average of \$189 million<sup>56</sup>, is too high to procure it in numbers to replace aging legacy fighters.

The F-35's development history also includes a 14 percent decrease in orders, a 38 percent increase in unit cost between 2001 and 2006, and an 18 percent increase in total procurement costs in spite of cuts in the procurement goal.<sup>57</sup> Given this, and the Air Force's problems in managing any major procurement program in recent history, such a goal seems to be less than a reliable basis for estimating program costs.

Industry sources contend these numbers, however, and note that in April 2008, the F-35 Joint Program Office's (JSFPO) Selected Acquisition Report (SAR) estimated that F-35 acquisition costs had dropped by nearly \$1 billion from 2006 to 2007. They add that 92 percent of the F-35 unit cost increases were due to changes in the procurement schedule, inflation indices, material cost increases, and labor rate increases.

**Figure 5: Air Force F-35 JSF Procurement Plan**



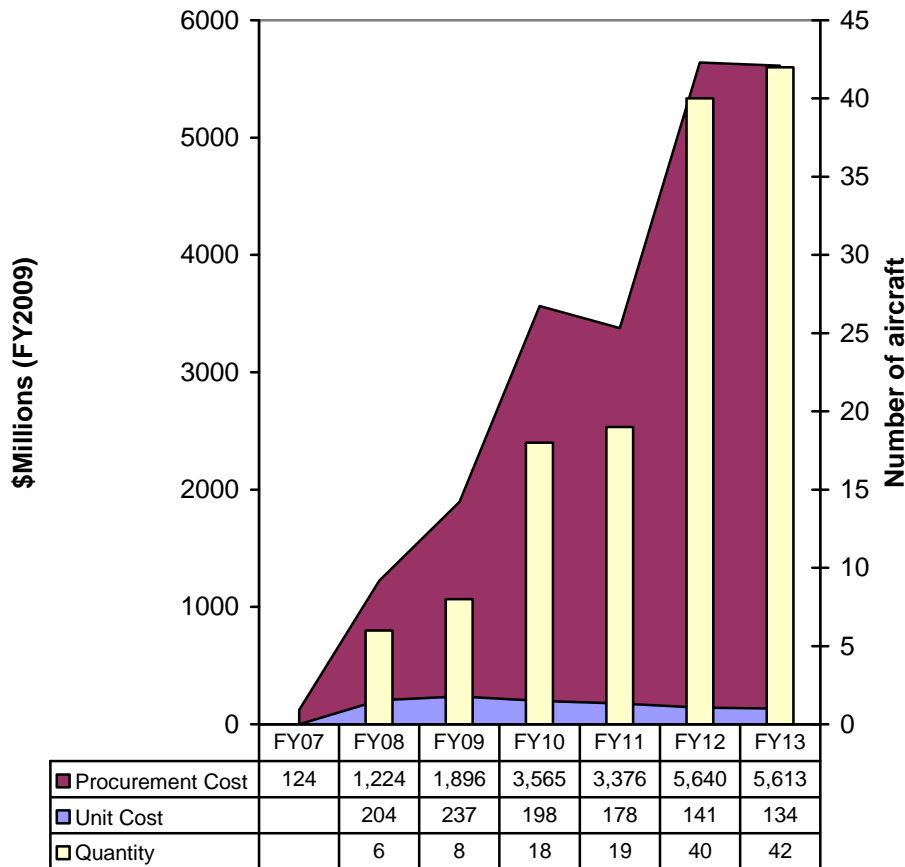
Source: United States Air Force, Committee Staff Procurement Backup Book – FY2009 Budget Estimates, Aircraft Procurement, Air Force, Volume I, February 2008, Exhibit P-40, p. 1-1.

*The F-35, the F-18 and the Navy Strike-Fighter Shortfall*

The story for the US Navy is more complex. The Navy is currently procuring F/A-18E/Fs and EA-18Gs in addition to the JSF. The former two airframes have been procured through five-year multiyear procurement arrangements. The current multiyear contract will expire at the end of FY2009 and it has not been renewed to date.

Unless these plans are changed, the JSF will be the Navy’s only tactical aircraft procurement program starting 2010. As **Figure 6** shows, this will make the Navy/Marine Corps program roughly as large and costly as the Air Force Program. All three services are betting their future not only on the F-35 as the key option for modernization of the bulk of their tactical air fleets, but on their ability to fund the necessary program at the necessary rate.

**Figure 6: Navy JSF Procurement and Costs FY2007-FY2013**



Source: Department of the Navy, Fiscal Year 2009 Budget Estimates, February 2008, Exhibit P-40.

Figure 7 shows just how important the F-35 is to the Navy. The Marine Corps will be even more reliant on the JSF, as it does not fly the updated F/A-18D/F models. It only flies the older F/A-18C/D models and AV-8Bs, both of which are reaching retirement age. Figure 7 shows the Navy’s JSF and F/A-18 procurement and the Marine Corps’ JSF procurement until FY2013. The 680 JSFs planned for the Department of the Navy include 420 F-35’s for the Marine Corp and 260 F-35’s for the Navy. The mix of F-35B’s and F-35C’s for the Department of the Navy is yet to be determined

The F-35’s impact on the Navy and Marine Corps is compounded by the fact that the current inventory of Navy strike-fighters falls short of the number Navy officials deem necessary to support requirements for the ten active-duty aircraft carrier wings (CVWs) and three active-duty Marine air wings.

The current shortfall of about 15 aircraft is a result of early retirements of legacy aircraft due accelerated usage since 2001, and poor strategic planning. The Navy projects this shortfall to rise to around 30 aircraft in FY2009, 50 in FY2016, and to over 90 aircraft in FY2017-2020, with a peak of 125 aircraft in FY2017. 69 of the latter number will be

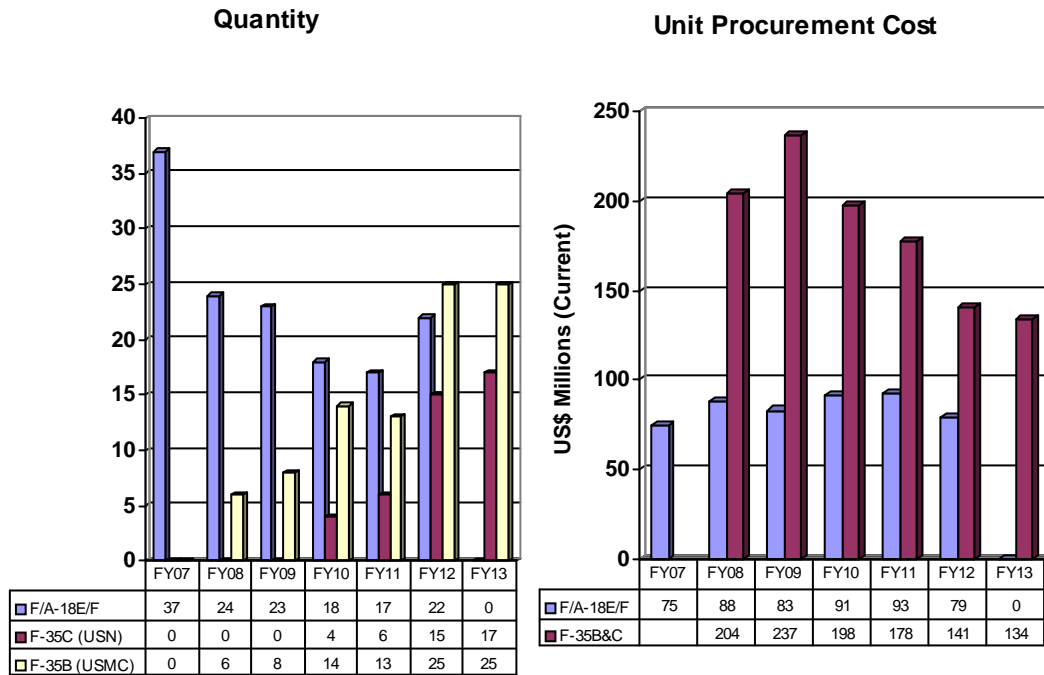
Navy strike-fighters, which would reduce the number of active-duty CVWs from ten to seven during the period between 2016 and 2020.<sup>58</sup>

Congressional Research Service studies note that industry sources project the strike-fighter shortfall to be roughly twice as large as the Navy's estimate. The difference is due to doubts about the Navy's assumptions, which its "most optimistic"<sup>59</sup> projections are based on. Central to the Navy's projection is the assumption that an extension of the F/A-18C/D's service life can be extended from the current planning figure of 8,000 flight hours to 10,000 flight hours.<sup>60</sup> Originally, Navy plans only foresaw 6,000 flight hours for the F/A-18A/B/C/D models but adjusted that figure to 8,000 hours in 2006. It is still unclear whether a service-life extension to 10,000 flight hours is feasible.

Navy plans also assume a prompt delivery of the JSF and a production rate of 50 aircraft per year. Some industry sources doubt this assumption, considering the risks in JSF production, while others believe the program will be able to meet all three services, IOCs. A decrease in numbers produced would raise the unit costs and limit the Navy's budgetary ability to procure 50 JSFs a year. At a number of 35 aircraft per year, the strike-fighter shortfall could increase to as many as 120 aircraft in FY2016 and 229 in FY2022. This would reduce the number of CVWs further down to six between 2016 and 2020.<sup>61</sup>

The Navy is considering an option to buy more F/A-18E/Fs to fill the gap. Although such aircraft have a significantly lower unit price, such an option only pulls on one end of the string. Less JSFs for the Navy will increase unit costs for the JSF and put further budgetary pressures on the Marine Corps and the Air Force, for whom the F/A-18E/F is not an alternative. Such a decision might set off a cost increase spiral for the JSF as foreign buyers might also retract from pledged funds. 738 aircraft are expected to be purchased by the United Kingdom, Australia, Italy, Canada, Denmark, Turkey, Netherlands, and Norway.<sup>62</sup>

**Figure 7: Navy F/A-18E/F and F-35 Procurement Costs**



Source: CRS, Navy-Marine Corps Strike-Fighter Shortfall, RS22875, updated 1 August 2008, p. 2.

*The Peer Threat to US Military Aviation From the US Congress*

As is often the case, the Congress has also played a role in increasing the peer threat that the US poses to US military aviation. The Pentagon’s plan to go forward with the development of the F-35 differs from lawmakers’ preferences. The Pentagon’s plans would have saved the money to produce two additional planes for testing purposes.

The House Appropriations Subcommittee, however, cut \$786 million – or four planes – from the Pentagon’s budgeted \$3.7 billion intended to purchase 16 aircraft in FY2009. Instead, lawmakers added \$320 million for two additional flight-test planes. This emphasis on thorough testing should avoid costly surprises of increased costs due to under-tested systems, as the Navy in particular is experiencing.

*Meeting Schedules and Costs at the Expense of Testing*

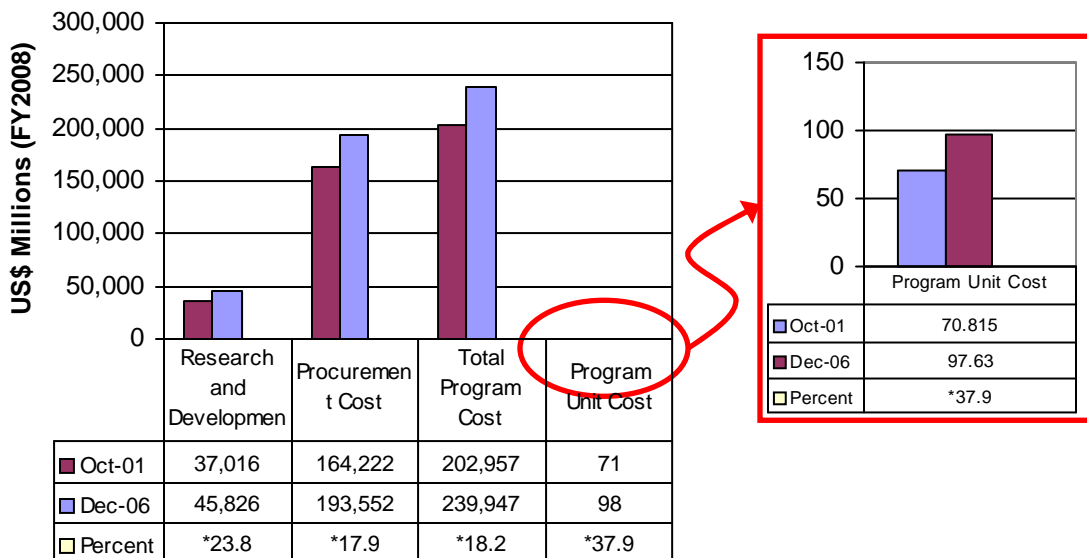
Cutting on expenses for testing has become a common practice to meet tight schedules and reduce costs before. DoD cut the number of test aircraft and flight test hours in 2007 in an attempt to control planned schedules and costs. In a study published in March 2008, the GAO found that “[v]ery little flight testing has occurred to date and the first fully integrated aircraft will not begin flight testing for at least four years.”<sup>63</sup> Industry sources state, however, that the first fully integrated aircraft will begin flight testing this year.

**Cost growth and Technology Maturity**

GAO studies conclude that this lack of testing exposes the program to “significant risk”<sup>64</sup>. This risk comes in the form of costly potential changes to design and manufacturing processes. Of six critical technologies, only two were mature at the date the GAO study was published. Three of those technologies were still immature, six years into the system development process. Maturing these critical technologies during development has incurred significant cost growth. The electric-hydraulic actuation and the power thermal management systems are two of the three critical and immature technologies mentioned above. They have experienced cost growths of 195 and 93 percent since 2003, respectively. Since the GAO study was concluded, both systems have been integrated and are flying today in two variants of the aircraft, according to industry sources.

Immature technologies can lead to delays and may require design and production changes. A lack of testing certainly exacerbates this. According to the GAO study, the total program costs have increased by 18.2 percent, the unit cost has gone up by 37.9 percent for 14.2 percent less aircraft than originally planned in 2001. These patterns of cost escalation are shown in **Figure 8**.

**Figure 8: Joint Strike Fighter Program Cost Growth**



Source: GAO, *Defense Acquisitions*, GAO-08-467SP, March 2008, p. 105.

These cost increases of the F-35 program are largely due to a one-year extension in the program’s System Development and Demonstration phase and the subsequent one-year delay in delay in procurement, reduced annual production numbers, and revised labor and overhead costs. Overall, CRS estimates the cost increase reached \$100 billion, since 2002.

Development of the STOVL variant has been one driving force behind the cost increases. Much of the schedule slippage was caused by addressing weight-related performance issues of the F-35B. Specifically, developing the engine for the Joint Strike Fighter as incurred cost overruns of as much as \$850 million, according to United Technologies Corp. whose Pratt & Whitney unit builds the F135 single engine for the aircraft. This corresponds to a 14.7 percent increase in the company's \$5.8 billion development contract.<sup>65</sup> The Pentagon's estimates of the cost overrun were \$150-200 million lower than United Technologies'.<sup>66</sup>

The aircraft's engine has been the subject of Congressional debates, since its development start. Congress issued a direction in 2006 to develop an alternative engine program to compete with the F135 Pratt & Whitney model. However, DoD removed funding for the alternate General Electrics/Rolls Royce F136 engine repeatedly from its FY2007, FY2008, and FY2009 budgets, citing net cost-benefit considerations.<sup>67</sup> Now the Pentagon has no alternative to the F135 and the corresponding cost overruns.

## ***V-22 Osprey***

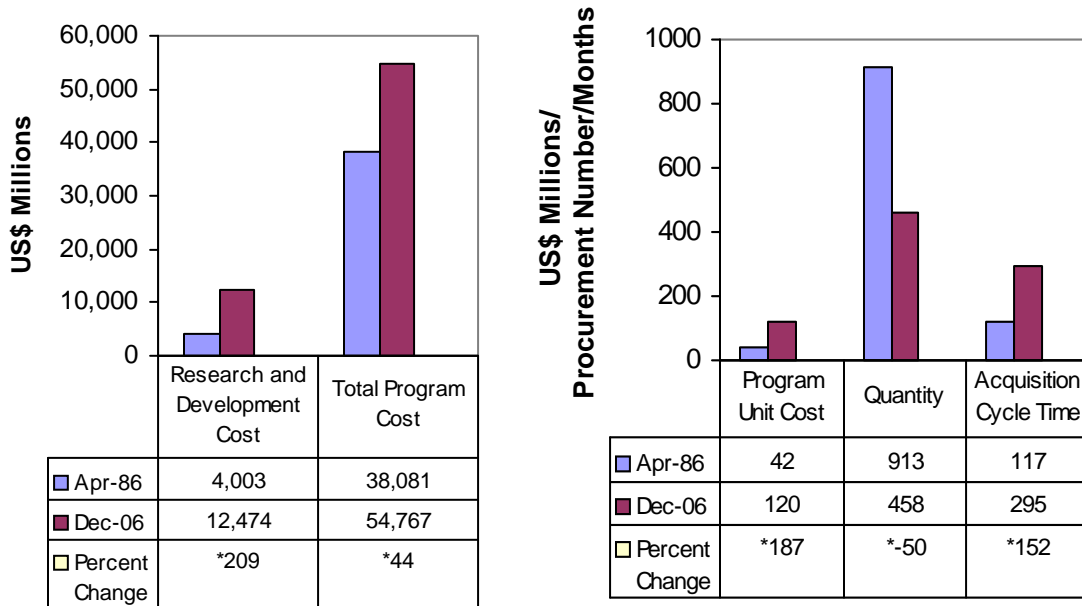
The V-22 Osprey is a top Marine Corps' procurement priority. The V-22 is a tilt-rotor aircraft with increased performances in speed and payload, which has long been scheduled to replace the aging CH-46 Sea Knight helicopter the Marine Corps currently operates. It can take off and land vertically, but tilts its rotors to in forward flight like a conventional fixed-wing aircraft. It is intended to execute a variety of missions for the Marine Corps, the Navy, and the Air Force, including troop and equipment transport, amphibious assault, search and rescue, and special operations. The respective variants, MV-22 (USMC) and CV-22 (USAF) have some 90 percent commonality with the major differences being in avionics.<sup>68</sup>

### ***A Long History of Trouble, Delays, and Cost Escalation***

The V-22 has been heavily criticized throughout its development due to recurrent technical problems, delays, and high costs. The system development phase took 25 years, cost over \$18 billion and claimed the lives of 30 people in four crashes of flight tests.<sup>69</sup> Critics have typically pointed out the system's high cost, technical problems that cause the aircraft to descend slowly, making it vulnerable to ground fire, and its combat inefficiency, given the high costs.

The V-22's history of cost escalation is shown in **Figure 9**. The aircraft is currently five times more expensive than the system it replaces – the CH-46 helicopter from the 1970s – and has a unit price of \$100 million.<sup>70</sup> The Osprey is also three times heavier than the helicopter it replaces. Compared to contemporary helicopters the aircraft appears even less impressive.<sup>71</sup> A particularly critical feature in *Time* magazine was titled “A Flying Shame – After an investment of \$20 billion, 25 years and 30 lives, the V-22 Osprey arrives in Iraq to make its combat debut – lacking both firepower and the ability to land safely if it loses power at low altitudes.”<sup>72</sup>

**Figure 9: The V-22 Cost Explosion Between 1986 and 2006**



Source: GAO, *Defense Acquisitions – Assessment of Selected Weapon Programs*, March 2008, p. 167.

The aircraft was grounded repeatedly after test vehicles crashed. At one instance in 2000, the Marine Corps grounded test aircraft for 18 months after 23 Marines were killed in a crash.<sup>73</sup> Investigations uncovered various scandals, including the falsification of maintenance records and three Marines found guilty for misconduct, and a company indicted for supplying titanium tubes with falsified quality certificates. Replacing the tubes cost \$4 million, according to *Time*.

***Cutting Requirements to “Fix” Technical Problems***

There have been significant slippages in production schedules. In 2001, a Blue Ribbon panel, formed by then-Secretary of Defense William Cohen, found the aircraft not maintainable or ready for operational use. It recommended continuing the program at a minimal rate to give it time to sort out the technical problems.

The FY2002 National Defense Authorization Act codified the minimal rate of production of 12 aircraft per year. This would be just enough to keep the production line open. The panel also recommended the transfer of acquisition authority from the Navy to DoD Undersecretary Pete Aldridge. Renewed testing and mechanical adjustment further slowed the development and increased the program’s cost.

Finally, the Navy and Marine Corps reduced some requirements to allow the aircraft to reach operational readiness. “[T]he V-22 [was] no longer required to land in helicopter mode without power (also known as ‘autorotation’), protection from nuclear, chemical and biological weapons [had] been eliminated. The V-22 [was] no longer required to



have an ‘air combat maneuvering’ capability; instead it must demonstrate ‘defensive maneuvering.’ Also, the requirement that troops be able to use a rope or rope ladder to exit the cabin at low altitudes [had] been eliminated.”<sup>74</sup> The *Time* article cited earlier described the change in autorotation capability as follows, “unable to rewrite the laws of physics, the Pentagon determined that the ability to perform the safety procedure was no longer a necessary requirement and crossed it off the V-22 must-have list.”<sup>75</sup>

### *The Affordability Issue*

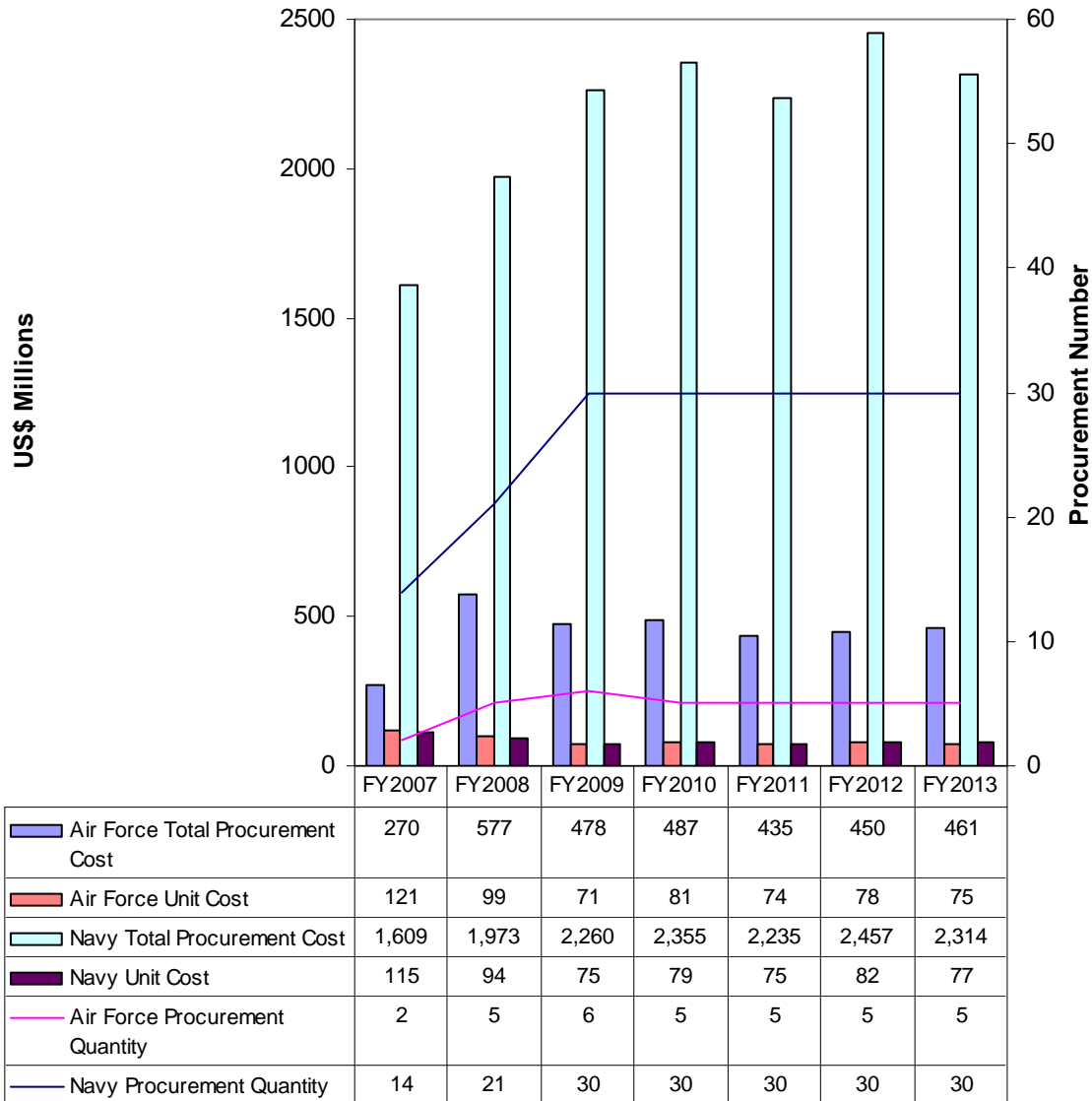
Original plans called for the production of over 1,000 aircraft within 10 years at unit cost of \$40 million. Rising costs led the Army to abandon the project in 1983 adding more budgetary pressure on the program.<sup>76</sup> Further cuts, cost increases due to technical problems and a drawn-out development led to attempts by then-Secretary of Defense Dick Cheney to cancel the program between 1989 and 1992. Throughout its development, however, the V-22 enjoyed broad and persistent Congressional support. The V-22 program has nearly 2,000 suppliers in over 40 states<sup>77</sup> and created jobs in 276 congressional districts.<sup>78</sup>

A second operational evaluation (OPEVAL) in June 2005 finally recommended declaring the V-22 operationally suitable and effective for military use. Due to the high unit cost, however, production plans had to be cut and will reach a stable annual procurement rate of 30 aircraft for the Navy in FY2009 and 5 aircraft for the Air Force in 2010.

The President’s FY2009 budget request is summarized in **Figure 10**, and calls for the entire program to reach 408 aircraft for the Navy (360 of which will serve the Marine Corps), and 50 aircraft for the Air Force (co-funded by the Air Force and USSOCOM) It estimates that the aircraft can be delivered at an average unit cost of \$87 million.<sup>79</sup>

Like all current estimates of aircraft costs, the ability to achieve a unit cost this low is extremely questionable. Even if it is achieved, however, the V-22 will still be costly compared to alternative systems such as the S-92, or upgraded CH-53, or EH101 helicopters that have been discussed before. Given increased budgetary pressures from other programs, the current procurement goals are also questionable and unit costs might again increase if the numbers are cut. Furthermore, even current unit costs are so high that it is difficult to attract foreign buyers.

**Figure 10: FY2009 FYDP for V-22 Procurement**



Source: Undersecretary of Defense (Comptroller), United States Air Force Committee Staff Procurement Backup Book, FY2008/2009 Budget Estimates, February 2008, Exhibit P-40, p. 4-5, and Department of the Navy Fiscal Year 2009 Budget Estimates, February 2008, Exhibit P-40, p. 1.

### *VH-71*

The VH-71 is supposed to replace the Presidential helicopter fleet, and the aircraft is dubbed “Marine One” whenever the President uses the aircraft. The current fleet is old and needs to be replaced. However, unrealistic and changing requirements, coupled with cost and development problems, have left the service with a helicopter that comes at a unit price of \$400 million, almost as much as the President’s Boeing 747 Air Force One, even after adjustment for inflation.

The bulk of the current fleet of 27-Sikorsky VH-3Ds is nearing their 30th in-service anniversary. The eight VH-60N Whitehawks are slightly less aged but some of the older aircraft were in service under President Ford. Although these aircraft are not exposed to the same kind of attrition as a combat aircraft, 30 years in service take their toll in terms of safety and operational readiness. The *Washington Post* cites an incident in 2006 where the President had to divert to a car since Marine One could not get off the White House lawn.

The program for a new Presidential helicopter was launched in the wake of September 11. The White House commissioned the development of a flying command and control center, stressing the need for constant and instant communication capability. According to one news article, the government's requirements amounted to "a combination of flying main battle tank and airborne command-and-control center in the time of national crisis, with on-board encrypted broadband Internet and video-conferencing, among other things."<sup>80</sup> The other things include the ability to jam heat seeking devices, fend off incoming missiles, and resist some of the electromagnetic effects of a nuclear blast.

These performance requirements added up to a system that "may not be executable ... considering costs, schedule, and performance trade-offs," according to a GAO study in 2007.<sup>81</sup> The study concluded that "[c]oncurrency in development, design, and production continues to put the program at risk for cost growth and schedule delays." A year later an update of the GAO study left its bottom-line assessment of the program unchanged, regarding the production of Increment I.<sup>82</sup>

John J. Young, Jr., the Undersecretary of Defense for acquisition, responded that "[t]he Navy and industry team did not clearly realize the full implications of the White House requirements."<sup>83</sup> An aviation news and data provider suggested that "the misunderstanding occurred because the US Navy source-selection team was kept separate from the rest of Navair during the VXX competition. While the plan was to buy an off-the-shelf helicopter for Increment 1 aircraft, then upgrade it for Increment 2, Navair subsequently required additional modifications and testing."<sup>84</sup>

These requirements also sharply raised the price tag of the program to \$4.2 billion for the original 18-aircraft program.<sup>85</sup> The British have bought the same base-model of the Augusta/Westland for \$57 million, each, according to the Miami Herald, although it must be noted that the British variant was never intended to serve the same purpose as the US Presidential helicopter.<sup>86</sup> After a reassessment of the program, the plans now call for the fielding of five Increment 1 aircraft, which will then be replaced by a fleet of 23 Increment 2 aircraft, once further design changes have been integrated. The result is five additional aircraft and a cost increase from \$6.1 billion in 2005, when the contract for Increment 1 was signed, to \$11.2 billion today.<sup>87</sup> According to these plans, President Obama may be the first to use a \$400 million Marine One helicopter, if production can start in 2010, as currently scheduled.

## **STRATEGIC CAPABILITIES: THE LONG RANGE BOMBER PROGRAM**

The current development and procurement program to develop replacements to the B-52, B-1 and B-bombers has not yet been publically defined.<sup>88</sup> The Air Force is, however, seeking to fund the development of a new long-range strike aircraft to be operational by 2018. Plans for the acquisition of such an aircraft were accelerated by 20 years following the Air Force's desire to retire 38 B-52Hs in the FY2007 budget request.<sup>89</sup> The Air Force has included some \$17 billion in its future procurement plans in order to fund such an aircraft.

The Air Force has stated that it needs this new aircraft to bridge a bomber capability gap. Today, the B-52H Stratofortress represents 52 percent of the Air Force's 181-strong bomber fleet. The B-52H served its first flight in 1954. The Air Force retains 62 B-52H for combat operations. However, they suffer from a number of age-related issues and spare parts are getting scarce.

Outside studies, like those done by the CRS, estimate the B-52H will not be "survivable under the 2015-2020 threat picture" despite a service life extension in 2007, which was expected to carry the B-52H into 2030.<sup>90</sup> The 2006 Quadrennial Defense Review called for a "land-based penetrating long-range strike capability [to] be fielded by 2018." The current bomber fleet should be modernized and the B-52 fleet reduced to 56.

Drawing the fleet down to 56 bombers was expected to generate \$680 million in procurement-related savings and a reduction of 3,924 related personnel. However, lawmakers would not approve of these plans and recommended prohibiting the Air Force from reducing the B-52 fleet below 76 aircraft.<sup>91</sup> With a renewed emphasis on the nuclear mission, the service announced plans to reactivate a squadron of semi-retired B-52 bombers for a one-year duty that will expose more airmen to the nuclear mission.<sup>92</sup>

In addition, the existing B-2 fleet will have to undergo expensive upgrades. The almost 20-year-old fleet will receive new flight computers, cockpit displays, and radar and communications gear among other upgrades. The X-band radio frequency used by the B-2 has been sold by the Federal Communications Commission to a commercial user. A new radar should be integrated into the first six bombers by 2010 and reach IOC for the entire fleet by the end of 2013. The cost of the radar project alone is about \$1.15 billion.<sup>93</sup>

Any new manned bomber program, however, will be under heavy pressure given the ambitious timeline announced in the 2006 QDR, and will have to compete with updates of the existing bomber fleets and programs like unmanned combat vehicles. It will also face funding pressure from other competing projects of the Air Force, such as the KC-X, CSAR-X, C-5 RERP, F-22, Joint Strike Fighter, and Joint Cargo Aircraft. The Secretary of the Air Force stated that executing the goal set in the 2006 QDR was going to be a struggle.<sup>94</sup>

## *A History of Past Liar's Contests*

The recent history of US bomber development is scarcely a reassuring one. It is almost impossible to estimate the real cost of either the B-1B or B-2. There is no clear way to distinguish what are legitimate expenditures for mission improvements and modernization from corrections made after the procurement of the aircraft to compensate for the gross mismanagement of both programs during the development and procurement phases.

### *The B-1 Story*

The B-1B is one of those rare cases where the Air Force systematically mismanaged a program by failing to modernize its specifications, and by trying to meet “on time, at cost” goals. The end result, however, was that the bomber was rushed into service without an effective test and evaluation program, and without properly modernizing its electronic warfare capabilities or its ability to perform conventional strike missions.

The end result was a defective aircraft that took years to rise to proper mission capability. A GAO study written in 1989 provides what seems to be the best official unclassified summary of the problems in performance and cost.<sup>95</sup>

In July 1980 the Congress directed the Secretary of Defense to vigorously pursue the full-scale engineering development of a new multirole bomber. Candidates included, but were not limited to, an advanced technology aircraft, the B-1A bomber canceled by the President in 1977, and derivatives of the B-1A and FB-11 IB/C aircraft. The Congress also directed that this multirole bomber be capable of performing strategic missions of penetration, cruise missile carriage, conventional bomber, and maritime support and that initial operational capability (IOC) be scheduled for not later than 1987.

On October 2, 1981, the President announced his decision to develop and deploy 100 B-1Bs. In selecting the B-1B, DOD believed that the technology, cost, and schedule risks would be low because of experience with the B-1A program. For example, about 80 percent of the B-1B airframe was planned to be common to the B-1A prototype, which had almost 1,900 flight test hours. On January 18, 1982, the President certified to the Congress that the B-1B would have an IOC in 1986 and that the development and acquisition cost of the B-1B fleet would be capped (i.e., not exceed) \$20.5 billion (in constant 1981 dollars). ... The Air Force declared the B-1B operational in September 1986 and received the 100<sup>th</sup> B-1B in April 1988. (The force has been reduced to 97 aircraft due to a crash in September 1987 and 2 crashes in November 1988.

In early 1987 we (the GAO) testified on the status of the B-1B program before the House and Senate Committees on Armed Services. We stated that despite production delivery successes, the performance of the aircraft at the time that the Air Force declared the first 15 operationally capable (September 1986) was considerably less than originally intended. We also said that development and production problems in B-1B subsystems limited testing, necessitated operational restrictions, and prevented some training. Much remained to be done before the development and acquisition was completed. During our testimony we discussed problems with the defensive avionics, flight controls, terrain-following radar, avionics integration, fuel leaks, and logistics support. We also testified that the initial ground rules and time frames for the program, particularly the requirement for near-simultaneous development and production, had created a severe management challenge for the Air Force. This program concurrency proved to be a contributing factor to many of the program problems that had developed. Finally, we stated that although the Air Force believed it had identified solutions to known performance problems, assurance that problems had been solved

would have to await successful completion of the test program. We noted that the revised test schedule extended testing 32 months to February 1989.

...Recently disclosed problems (in 1989) center on the system's radar warning receiver and processor function, which is intended to initiate defensive action by receiving and identifying threat system signals. Although specific flight test results and the extent of ALQ-161A limitations are classified, the problem originates with the basic system design. The program office believes that software revisions may allow limited performance improvements, but these revisions will not be able to overcome design deficiencies. As a result, a significant degradation of system capability exists.

...Although all 100 B-1B aircraft have been delivered, more money will be required to complete the system acquisition effort. To date, the Air Force has incurred costs of about \$31 billion in escalated dollars for 100 B-1B aircraft. This includes about \$3.7 billion in funds expended on non-baseline items such as simulators and interim contractor support. These items were excluded from the baseline by the Office of the Secretary of Defense when the program was established in 1981. Funds may also be needed for potential capability enhancements. The program office has estimated the cost of 14 potential enhancements at \$7.4 billion. Additionally, as shown in chapter 2, the Oklahoma City Air Logistics Center has identified needed modifications estimated to cost \$1.7 billion.

Looking through other reporting from GAO, and Air Force budget requests, it seems likely that the B-1B costs close twice the original Air Force estimate in constant dollars to bring to full operational capability.

In addition to correcting the major problems in the electronic warfare suite, the aircraft also had to be modified to deal with fuel leak problems, problems in flight control – particularly for its low altitude penetration mission, problems in the terrain following radar, problems with avionics compatibility, problems in weapons delivery and a list of other issues. Throughout this process, the air Force failed to provide realistic estimates as to the scale of the problems, the time and nature of the fix, and program cost.

It should be noted, however, the B-1B was, in fact, one of the few examples, of the downside of trying to meet program and cost objectives without effective program management. The Air Force froze critical mission requirements in high cost capabilities like the electronic warfare suite, and then failed to carry out a meaningful test and evaluation program in an effort to be “on time at cost.” The B-1B may show that there is more than one way to run a liar's contest, but a liar's contest is still a liar's contest.

### *The B-2 Story*

The B-2 story is more typical of the problems in other aircraft procurement and modernization programs. Another GAO study describes its problems (through 1998) as follows:<sup>96</sup>

The Air Force began development of the B-2A in 1981 and reported on June 30, 1997, after 16 years, that the development and the initial operational test and evaluation had been completed. The Air Force reports of the initial operational tests were completed in November 1997. In 1986, the Air Force estimated that B-2A development could be completed for \$14.5 billion, including a 4-year, 3,600-hour flight test program scheduled at that time to end in 1993. The flight test program ended June 30, 1997, and the estimated cost of the development program had grown to over \$24 billion and the flight test program to about 5,000 flight test hours over 8 years. The development and testing programs were extended because of Air Force changes in the B-2 requirements and various technical problems.

Major changes and problems contributing to the delays included:

- making the B-2A's primary mission conventional rather than nuclear;
- redesigning the aircraft to satisfy an added requirement to penetrate adversary air space at low altitudes;
- difficulty in manufacturing test aircraft, resulting in late delivery of partially complete test aircraft;
- difficulties achieving acceptable radar cross-section readings on test aircraft, which resulted in significant redesigning and retesting of certain components; and (5) correction of deficiencies in the aft deck structure because of the unanticipated effects of engine exhaust.

Even though numerous problems hindered the scheduled completion of B-2A development, production began with no flight testing having been completed. This resulted in substantial overlap of development and production. Test and production aircraft were delivered that did not fully meet the Air Force requirements, and a 5-year post-delivery modification program was initiated to update all aircraft to the block 30 configuration. Since production began in 1986, the planned number of B-2As was reduced from 133 to 21 aircraft and both the total development and the average unit procurement costs increased. Table 1 shows the change in estimated total and unit cost from 1986 to 1998.

**Table 1: Comparison of B-2A Program Total and Unit Costs Between 1986 and 1998**  
Millions of then-year dollars

| Acquisition element | 1986 (133 aircraft) |           | 1998 (21 aircraft) |           |
|---------------------|---------------------|-----------|--------------------|-----------|
|                     | Total cost          | Unit cost | Total cost         | Unit cost |
| Development         | \$14,500            | -         | \$24,700           | -         |
| Procurement         | \$43,700            | \$329     | 19,600             | \$933     |
| Total               | \$58,200            | \$438     | \$44,300           | \$2,110   |

The last two of the 21 B-2As were delivered to the Air Force in the block 30 configuration. The major effort remaining in the B-2A acquisition program is modification of the other 19 B-2As to the block 30 configuration, scheduled for completion in July 2000. Through April 1998, six B-2As have been delivered in, or modified to, the block 30 configuration and were operational at Whiteman Air Force Base, Missouri. Ultimately, the Air Force plans to have 21 B-2As, of which 16 will be available for missions (2 squadrons of 8 aircraft), and 5 will be in various maintenance and repair cycles

Once again, it is not possible to distinguish legitimate improvements from programs that were necessary because of design failures, undercosting, problems in program management, and failures to conduct adequate test and evaluation. It seems clear, however, that the B-2B escalated in cost by a factor of at least 300%, and it is all too clear that a potentially critical program was reduced to roughly one fifth of its original force goal, while the Air Force proceeded with a B-1B design that it had mismanaged and for which it had far less need.

Some teething problems are inevitable. This level of problems is a warning of what happens when programs spiral out of control.

## *Some Stealth, Less Strength*

The US now has a limited number of B-2 stealth bombers, but a significantly smaller total number of bombers than in the past. The trends involved, as well as those in average aircraft age, are shown in **Figure 11**.

Partly because bombers ceased to be a critical part of the nation's strategic nuclear forces, the Department of Defense has reduced its recommended bomber force structure in various white papers and roadmaps the number dropped from 211 aircraft in the 1992 Air Force Bomber Roadmap, to 157 in the 2001 Air Force White Paper. The 2002 Nuclear Posture Review excluded the fleet of 60 B-1B as a platform for strategic nuclear weapons delivery, but did not affect force numbers.

The 2007 Air Force White Paper set a goal of 167 bombers, including 76 B-52H. The Air Force's White paper called for investing \$4.1 billion in legacy bomber modifications over the 2008-2013 Future Year Defense Plan.

The 2008 National Defense Authorization Act issued guidance to maintain 63 B-52H operational. The Conference Report noted:

“The conferees believe that a B-52 total aircraft of less than 76 aircraft is not sufficient to meet combatant commander requirement for conventional long –range strike requirements if the need should arise to conduct near simultaneous operations in two major regional conflicts. The conferees strongly discourage the Secretary of the Air Force from taking action to reduce the B-52 aircraft inventory below 76 total aircraft prior to the next generation bomber reaching initial operational capability status and strongly oppose a strategy that reduces conventional long-range strike capability.”

The FY2009 Budget Request contains funding for only 56 operational B-52 bombers. It further contains no funding for the Next Generation Bomber. The Air Force confirms that it will not have the necessary funds to integrate existing technology into the bomber program until FY 2010.

## *Time for a New Paradigm?*

It does not take great vision to foresee how easily the next bomber program could repeat the disastrous technology risk, cost escalation, cutbacks in force goals, and delays in effectiveness that characterized the B-2. The B1-B and B-2 programs became development and procurement nightmares, but the mismanagement of the B-2B program sharply limited a key stealth mission capability by forcing massive cuts in the number of bombers that could actually be produced.

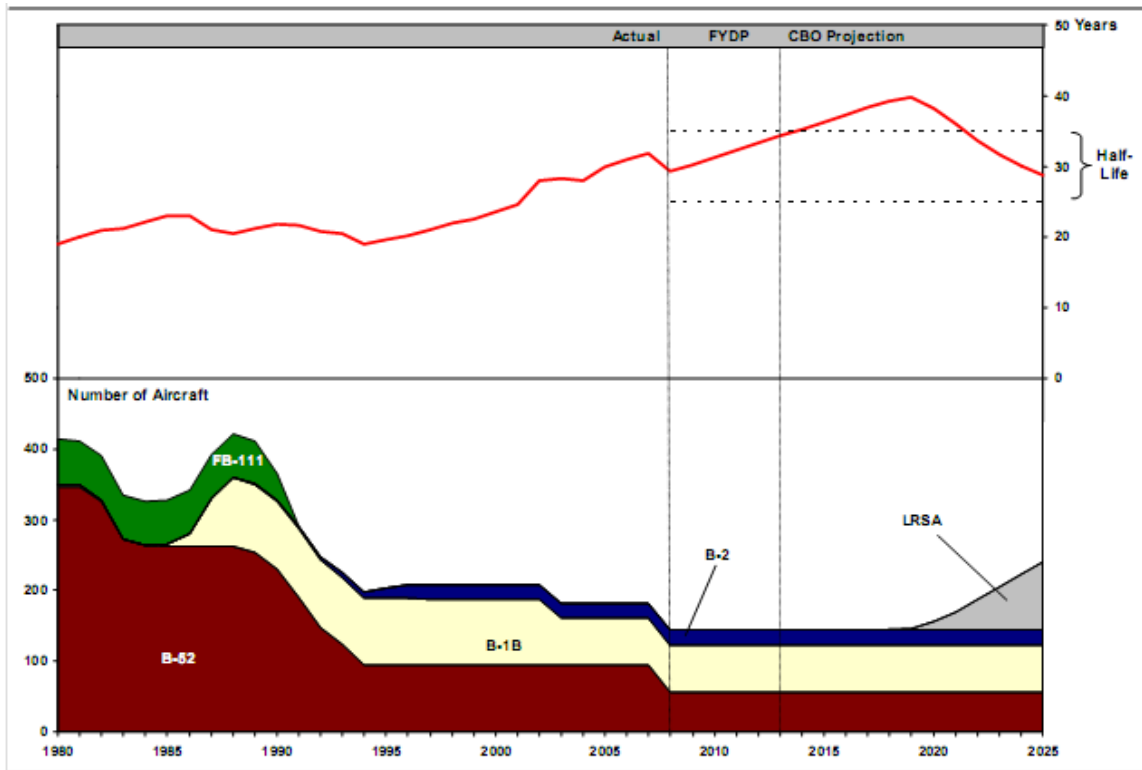
The Air Force, Navy, and Marine Corps cannot zero base the F-22 and F-35. The Air Force can, however, zero base its approach to developing and producing a new bomber. It can make it clear from the outset that the Secretary and Chief will be held personally responsible for the honesty and integrity of every element of the program, and that they will personally be dismissed if there is any major problem in cost containment, technology, performance specifications, and delay.

The British have a concept of Ministerial responsibility where accountability begins at the top, and Ministers must resign in the face of major failures regardless of whether they



are responsible. A similar “no excuses” approach to aircraft development and procurement is an experiment that may well be worth trying.

**Figure 11: Age and Inventory of Air Force Bombers**



Source: CBO, *The Long-Term Implications of Current Defense Plans*, March 2008, p. 28.

## ENABLERS: THE “KC-X” TANKER PROGRAM

The US tanker program affects a critical mission in global power projection. As **Figure 12** shows, it also affects a mission area with aircraft that have one of the oldest average ages of any key mission category. Unfortunately, tanker modernization has also become the most troubled single aspect of US military aircraft modernization. Efforts to lease new aircraft from Boeing produced the worst single procurement scandal in recent decades. A grossly mismanaged procurement effort, and award of the KC-X tanker contract to EADS/Northrop Grumman, forced cancellation of the award and was followed by major delays to restarting the competition.

### *Looking at the Past*

Once again, it is important to consider the problems the US has had in the past. The C-5, the C-17, and modernization of the C-130 all had major problems in performance, technology risk, delay, and cost escalation. None of these problems have approached the scale of those in the KC-X, but it is worth considering what happened to the C-17 program as an indication of future risk. A GAO study dating back to 1995 notes that,<sup>97</sup>

In 1981, DOD identified a need for additional long-range airlift and established a fiscally constrained airlift goal of 66 million ton-miles per day. At that time, long-range airlift capacity was about 29 million ton-miles per day. To reach the goal, the Air Force procured 50 C-5Bs and 44 KC-10 aircraft and began developing a new airlifter, the C-17.

The Air Force originally planned to acquire 210 C-17 aircraft. However, in April 1990, as part of DOD's Major Aircraft Review, the Secretary of Defense reduced the program to 120 aircraft—a sufficient number to maintain an airlift capacity of 52 million ton-miles per day, which was judged to be sufficient in the post-Cold War era. Through fiscal year 1995, Congress has appropriated almost \$18 billion for the C-17 program.

Due to cost, schedule, and performance concerns, the Deputy Secretary of Defense recently reduced the program to 40 aircraft, pending a Defense Acquisition Board review currently scheduled to occur in November 1995. The Air Force, however, is still planning for a 120-aircraft program. This report is intended to be used in congressional oversight of the pending decision. The provisional 40-aircraft program is estimated to cost \$22.5 billion, an additional \$4.5 billion over the amount appropriated through fiscal year 1995.

...In December 1992, total program costs were estimated to be \$39.5 billion (in then-year dollars) at a maximum rate of 16 aircraft per year. In January 1994, the C-17 program director estimated that total program costs would increase to \$43 billion because of a reduced procurement rate of 12 aircraft per year and increased estimates for production and support costs. DOD's paper indicated that, at a maximum production rate of 12 aircraft per year, total program costs would be \$45.4 billion. This increase is attributable to increased production and support costs and the cost of a recently approved business settlement between DOD and McDonnell Douglas. If the maximum procurement rate were reduced to eight aircraft per year, DOD's paper estimated that total program costs would increase another \$2.6 billion, to about \$48 billion. In recent years, due to ongoing development and production problems, Congress has reduced funding to slow the C-17's production rate to reduce the level of concurrency in the program. While the Air Force's desired procurement rate may eventually be achieved, the program has been significantly more stretched out than originally planned.

The C-17 procurement cost estimates reported in DOD's paper are significantly higher than those in the C-17 COEA. DOD's paper indicates that estimated procurement costs have increased by \$2.8 billion to \$4 billion (in constant fiscal year 1993 dollars) since the C-17 COEA.

These comments only take the aircraft up to the problems that existed in 1995. Like the B-2 and many other US tactical aircraft programs, the C-17 eventually became a major success. Nearly three decades after the original requirement was set in 1981, however, the Air Force does not have a stable program for airlift at a time when two wars involving massive airlift – and rapid aging of the entire fleet of airlift, tanker, and other “enablers” – presents major procurement problems. Moreover, C-17 production and procurement remain serious issues.

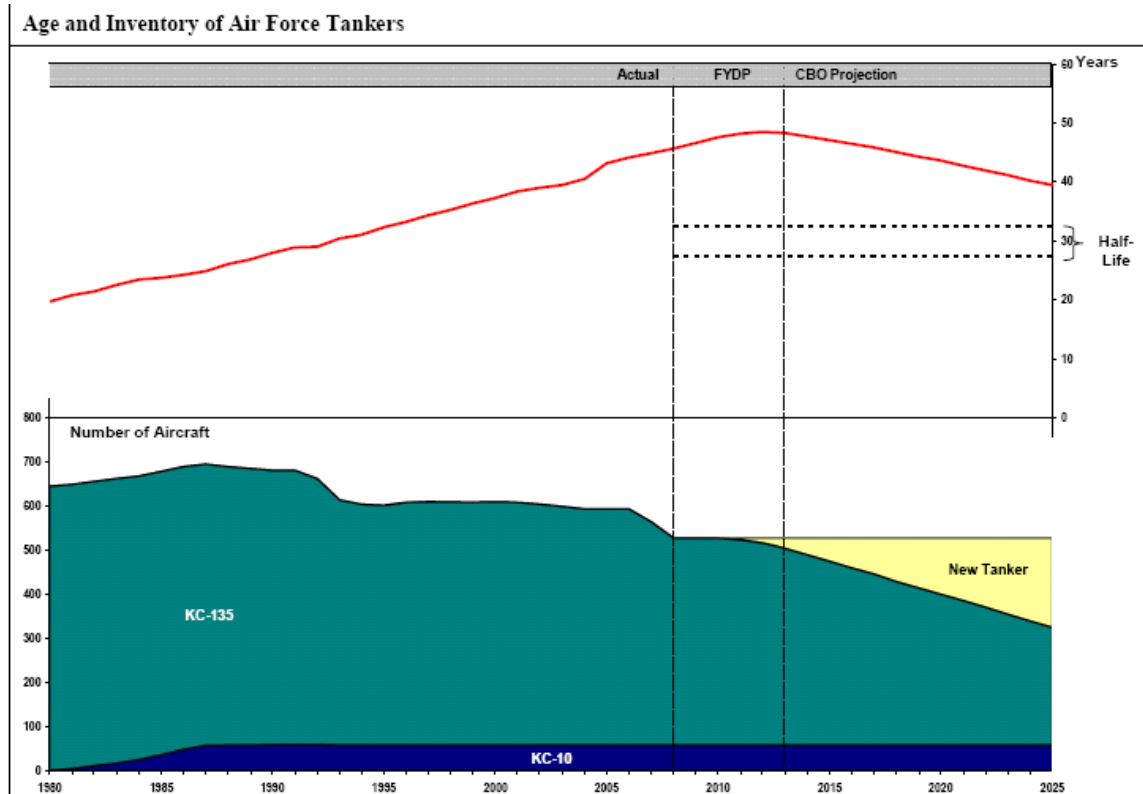
### ***Moving Towards the Future: The “X” in KC-X***

The goal for the KC-X program has been to replace the aging KC-130 and KC-135 fleet by 2045, if the program succeeds on schedule. The legacy tanker will by that time be 80 years old. Even today, maintaining an aging fleet that is in constant service throughout the world, and which is a key “enabler” to US forces, is affected by the increasing scarcity of spare parts. Overhauls and replacements of equipment are becoming more costly. Operation and maintenance costs also generally involve more personnel for older equipment. Maintaining an older fleet, as opposed to procuring newer more complex systems, thus entails more work to keep fewer planes less ready.<sup>98</sup>

The collapse of Air Force efforts to manage an effective competition in 2008 has forced the Secretary of Defense to defer the competition for the KC-X to the current Administration. They have also again opened up the question of what kind of tanker the Air Force should buy, how large it should be, cost, and how to judge technology and cost risk.

What is clear is the current size of the force and need for a new aircraft:

- The Air Force refueling tanker provides strategic in-air refueling services to all DoD aircraft.
- The Air Force's tanker inventory consists of 59 KC-10A Extenders, 85 KC-135E and 418 KC-135R Stratotankers. The KC-135 first entered service between 1957 and 1965 and is among the Air Force's oldest aircraft today.
- The Air Force planned to procure 179 refueling tankers for a total expected cost of approximately \$35 billion.
- The now cancelled initial \$12.1 billion contract, awarded to EADS and Northrop Grumman, provided for the purchase of the first 68 aircraft of the type of a modified Airbus 330-200.
- Although various studies found that the KC-135 aircraft would be viable until the 2040s, a GAO report that KC-135 flying hour costs increased by 29 percent between 1996 and 2002, even when adjusted to constant 2002 dollars.<sup>99</sup>

**Figure 12: Age and Inventory of Air Force Tankers**

Note: CBO assumes that the Air Force will continue to replace its aging tanker fleet beyond the current plans of 179 KC-X aircraft. The figure shows that the average age of the Air Force's tanker fleet will steadily decline with the start of delivery of the new KC-X tanker, but not reach the half-life level within CBO's projection period.

Source: CBO, *The Long-Term Implications of Current Defense Plans*, March 2008, p. 33.

### *The Overall Tanker Modernization Plan*

The Air Force has described the KC-X program as the first of three potential efforts to recapitalize the tanker fleet. "About 2023, the Air Force plans to contract for a second batch of tankers, dubbed KC-Y, and in 2033, it will go for the third or KC-Z batch, ultimately retiring all KC-135s along the way. This plan is summarized in **Figure 13**.

These plans have called for tanker purchases not to exceed \$3 billion a year. They have also indicated that the Air Force expects to be able to buy between 12 and 18 tankers per year, replacing the entire tanker fleet over 40 years."<sup>100</sup> It should be noted, however, that the plan potentially calls for either two additional tanker types or major modifications of the KC-X. Given the problems with the KC-X, this is a further illustration of the need for fundamental reforms the way senior leaders and officers manage aircraft development and procurement.

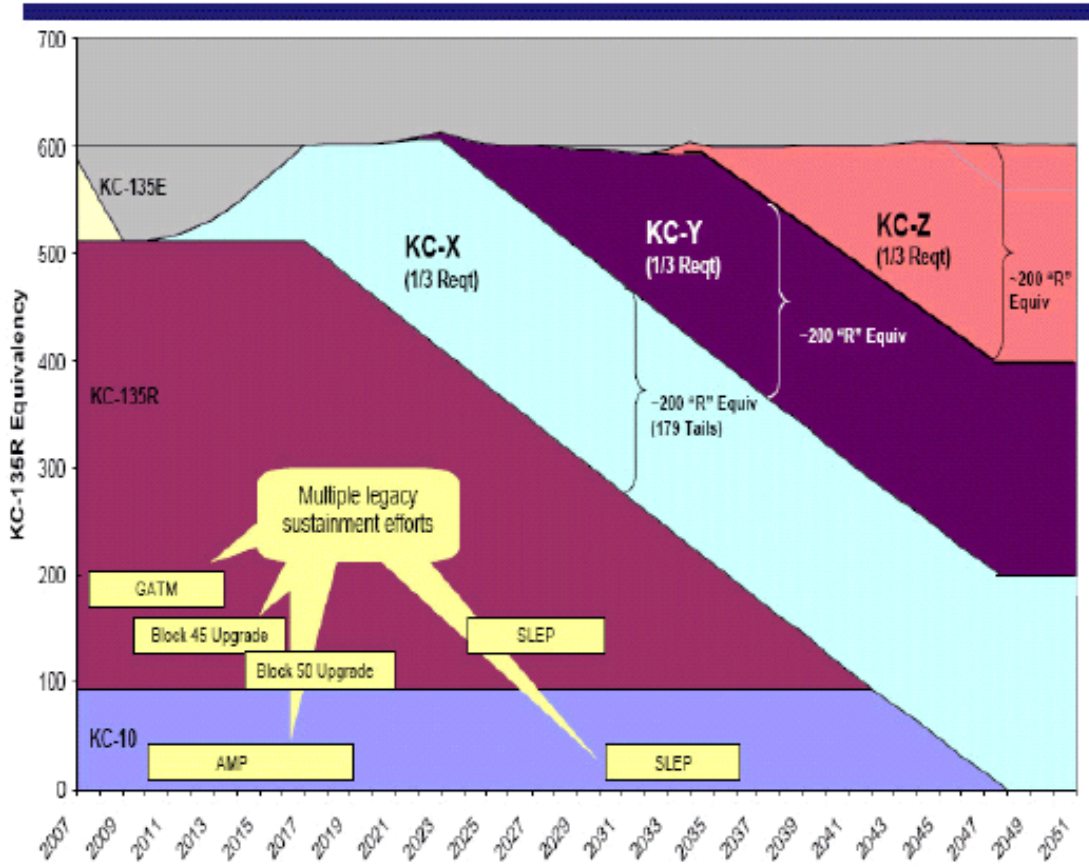
The GAO has criticized key aspects of such plans because, "the Air Force did not conduct a comprehensive business case analysis that fully considered life cycle costs in deciding its approach. Instead, the acquisition strategy was based primarily on budgetary

constraints – including limited available near-term funding for system development and a \$3 billion ceiling on future annual procurements.”<sup>101</sup>

A protracted debate around the KC-X contract could further delay and raise the cost of the entire the program. Former Air Force Chief of Staff Michael T. Moseley cited similar costs increased because of a protest regarding the CSAR-X helicopter in which the Air Force “lost \$800 million ... and over a year and a half of operational time because of not being able to field an airplane.”<sup>102</sup> Indeed, the 2008 NDAA allows the Air Force to retire the remaining 37 KC-135Es only upon the award of the KC-X contract and after any subsequent protests are settled favorably.<sup>103</sup>

There also are questions about research and development funding. Appropriators cut the requested funds for RDT&E twice in FY07 and FY08 from requested \$204 million to \$152 million and from requested \$314 million to \$114 million.<sup>104</sup>

**Figure 13: Air Force 40-Year Tanker Recapitalization Plan**



Source: “The 40-year Plan,” Daily Report, Air Force Association, 21 February 2008. Cited in CRS, *Air Force Air Refueling: The KC-X Aircraft Acquisition Program*, 4 March 2008.

## ***The Boeing versus Northrop/EADS Controversy***

The near terms challenges in creating an effective tanker procurement program are easily as great as those in shaping the overall modernization effort. On 29 February 2008, the Air Force awarded the \$35 billion contract to the EADS/Northrop Grumman team. Boeing Co. promptly submitted a formal protest against the contract award decision with the Government Accountability Office (GAO) on 11 March.

Under the Competition in Contracting Act of 1984 (CICA), the GAO had 100 days to decide a protest. In deciding a protest, the GAO's process differs from its general audit and review function and is handled solely by the GAO's Office of General Counsel (OGC).<sup>105</sup> The process is a legal one and addresses specific challenging particular procurement actions and that are alleged to flout procurement laws, regulations, and the evaluation scheme set forth in the solicitation. Although the Air Force's award also spurred a politically and emotionally charged debate, and a fierce public lobbying campaign by the two competitors, the GAO made its decision on this basis, and not on the basis of either political pressure and lobbying or an independent effort to assess which tanker would more successfully meet the Air Force's needs.

The GAO sustained Boeing's protest on 19 June 2008. It found that, "the Air Force had made a number of significant errors that could have affected the outcome of what was a close competition between Boeing and Northrop Grumman. The errors included not assessing the relative merits of the proposals in accordance with the evaluation rules and criteria identified in the solicitation, not having documentation to support certain aspects of the evaluation, conducting unequal and misleading discussions with Boeing, and having errors or unsupported conclusions in the cost evaluation."<sup>106</sup>

The GAO sustained the protest on eight counts:<sup>107</sup>

1. The Air Force identified the relative order of importance of requirements in the solicitation. Yet, in its evaluation of the companies' proposals, it did not apply the relative weighting in assessing their respective merits.
2. The Air Force relied on a key discriminator for making the decision – fuel offload versus unrefueled range – that was not consistent with the terms of the solicitation.
3. The Air Force failed to reasonably determine that Northrop Grumman's aircraft could live up to two key requirements – the necessary overrun speed and emergency breakaway procedures.
4. Boeing was not given equal opportunity to address shortcomings of their product. The Air Force revised their assessment of a key requirement parameter and found it insufficient. However, it did not communicate this reversal on their prior assessment to Boeing, thus depriving the company of the opportunity to address it.
5. Northrop Grumman took exception to a material solicitation requirement. It did not commit to plan and support the Air Force to achieve initial organic depot-level maintenance within two years after delivery of the first full-rate production aircraft.
6. As part of the solicitation the Air Force would calculate a most probable life cycle cost estimate for each firm's product. However, the calculations failed to account for the competitors' specific

- proposals, especially regarding the military construction component of the estimated life cycle costs.
7. The Air Force improperly increased Boeing's estimated non-recurring engineering costs in calculating that firm's most probable life cycle cost, but did not qualify Boeing's estimate as unrealistic.
  8. The Air Force used a model to simulate the growth of such non-recurring engineering costs. However, the inputs used in this model were found to be unreliable in predicting the anticipated growth in Boeing's non-recurring engineering costs.

The GAO's recommendation to the Air Force reads as follows:

"GAO recommends that the Air Force reopen discussions with the offerors, obtain revised proposals, re-evaluate the revised proposals, and make a new source selection decision, consistent with this decision. If the Air Force believes that the solicitation does not adequately state its needs, the agency should amend the solicitation prior to conducting discussions with the offerors. If Boeing's proposal is selected for award, the Air Force should terminate the contract awarded to Northrop Grumman. GAO also recommended that Boeing be reimbursed the reasonable costs of filing and pursuing the protest, including reasonable attorney's fees."<sup>108</sup>

In practice, the impact of this controversy and a faulty procurement process on the US force posture, has been far more important than the technical differences between the two aircraft. Even though the GAO report stated that differences in fuel burn rate could make a significant change in life cycle costs (not addressed in protest but recommended by GAO), and there were significant technical differences in size and capability, the end user of the aircraft did not regard them as important.

In early September 2008, Secretary Gates eventually pulled the plug and deferred the competition to the next administration. He stated before the House Armed Services Committee that "[o]ver the past seven years, the process has become enormously complex and emotional – in no small part because of mistakes and missteps along the way by the Department of Defense." He believes that a "cooling-off period will allow the next administration to review objectively the military requirements and craft a new acquisition strategy for the KC-X."<sup>109</sup> An October 31, 2008 memorandum to the service secretaries, Joint Chiefs of Staff and other senior Pentagon officials, Deputy Defense Secretary Gordon England projected a target date in March 2010 for an award of a new tanker contract.<sup>110</sup>

This adds to the delay and to the already heavy stress on the aging tanker fleet. General Arthur Lichte, who runs the Air Mobility Command, recently stated "I don't care which tanker wins. I just need a new tanker."<sup>111</sup> He made it clear that further delays in production and procurement of a new tanker will have a much more important impact on the Air Force. Lichte mentioned that another year of delays would mean that the Air Force had to fly some of its current fleet beyond 2040, making those planes over 80 years old.



The current Air Force budget envisages delivery of the first five KC-X tankers in in FY2010, and 12 more aircraft in FY2011. IOC was scheduled to be reached in 2014. With a March 2010 contract award, these dates will be pushed back beyond the end of this decade. Defense analysts stated that the Air Force has spent “a vast amount of time and energy to produce virtually nothing.”<sup>112</sup>

### ***Protest or Procurement***

This raises another key issue in improving US aircraft development, procurement, and modernization efforts. As Figures 14 and 15 show, all of the services have to deal with award and bid protests. The Air Force, however, has had more protests succeed than the other services.

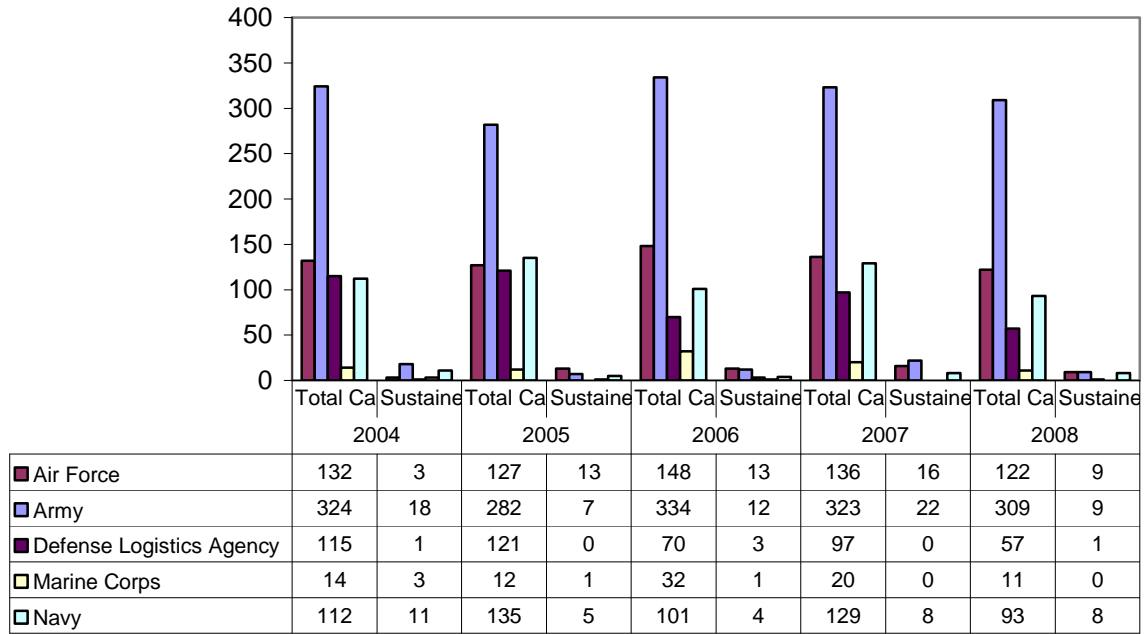
The contractors’ aggressive protest and the politicization of the Air Force’s procurement process is surprising and may set a dangerous precedent for the service’s acquisitions programs and complicate their recapitalization efforts. Acting Secretary of the Air Force Michael Donley said that the service needed a “new approach”<sup>113</sup> to select a bidder for the tanker contract. Secretary Gates cancelled the bidding between Boeing and Northrop Grumman, calling for a “cooling off period”<sup>114</sup> and effectively deferred the decision to the current administration. Thus the Air Force will enter the eighth year of trying to find a contractor to recapitalize the aging tanker fleet. It is now without a definitive timeline for the tanker recapitalization program.

Paolo Carmassi, a senior executive at the avionics manufacturer Honeywell pointed to the danger of the protracted acquisition process. Honeywell is involved roughly equally in both Boeing and Northrop projects. “This is a very significant precedent, which I believe will generate a follow-through for any major government award,” he stated. According to Carmassi, the process has dangerous implications for future procurement decisions in the United States, since “[a]ll parties will feel entitled to object, and that will end up slowing down the whole process for this and following deals.”<sup>115</sup>

The stakes are high in the tanker deal. “It is crucial to the health of our nation’s defense industrial base,” said Representative Duncan Hunter of California, the ranking Republican on the House Armed Services Committee.<sup>116</sup> Commensurate with the stakes involved in the tanker contract for all participants, the defense industrial base, the Air Force, and the tax payer, the Air Force’s acquisition team and leadership must assume responsibility for a sound award process.

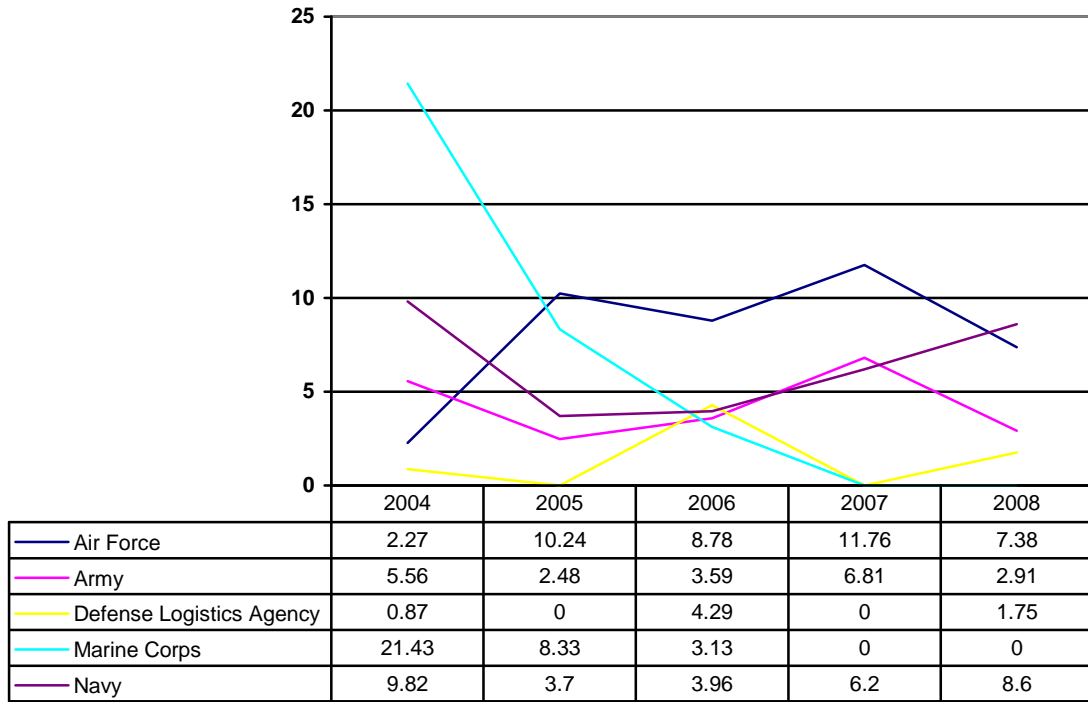
The Air Force leads the services’ ranking of sustained protests, as **Figures 14** and **15** show. Without clear requirements, criteria for the award, and a rigorous and consequential selection process, the services will expose their acquisition programs to a broad range of interest groups. Politicization and fierce competition between the contractors will eventually obstruct the services’ recapitalization efforts.

#### **Figure 14: GAO Bid Protests 2004-2008**



Source: GAO, *Air Force Procurement – Aerial Refueling Tanker Protest*, GAO-08-991T, 10 July 2008, p. 9-11.

**Figure 15: Sustained Protests in Percent of Filed Protests by Branches**



Source: GAO, *Air Force Procurement – Aerial Refueling Tanker Protest*, GAO-08-991T, 10 July 2008, p. 9-11.

## CONCLUSION

None of the peer threats to US military aviation are new. Underestimating technology, failing to set reasonable performance specifications and control the growth over time, appallingly bad cost estimation, and unrealistic development and production schedules have been critical problems in aviation since World War I. The same has been true of the misuse of analysis to justify given programs in the form of exaggerated threats, mission needs, and effectiveness. There is an inherent tendency to turn every procurement exercise into a liar's contest, sell the program by overpromising and undercosting, and create plans and budgets to match.

These trends shaped the formation of one of Norman Augustine's "laws" long before the current Administration or any of the new programs described in the paper were even a conceptual requirement: "In the year 2054, the entire defense budget will purchase just one aircraft. This aircraft will have to be shared by the Air Force and Navy 3-1/2 days each per week except for leap year, when it will be made available to the Marines for the extra day." It is interesting to note that while this "law" was formally published in book issued in 1983, when Augustine was then a leading aerospace executive, it was formed in the 1960s, when Augustine was an official in the Office of the Secretary of Defense.

Aircraft designs have to evolve. Not every risk is predictable, cost analysis will always be uncertain, and test and analysis will always have limits. The problem is not that the system is imperfect. The US has had many successes that began as deeply troubled program. The problem is that understating the risks in technology and production have grown steadily with time. There now are far fewer program alternatives if any key program runs into trouble, failed methods of cost analysis are still in play without adequate cost-risk analysis or use of regression analysis, and the pressure to "sell" programs by understating cost and risk have all combined to push air modernization to the crisis point. What Augustine originally said in semi-jest has become a major threat to US airpower.

This is not a crisis that can be blamed on any one Administration, and the nation's senior officials and officers did much during the eight years of the Clinton Administration to let things get out of control. The fact is, however, that the modernization of combat aircraft and "enablers" has gotten out of control under the Bush Administration, and has become a crisis where it is hard to find serious leadership.

This does not mean that process-oriented solutions do not have value. Better analysis and procurement reform may well help, although the impact of past efforts is questionable. One really looks at the claims of progress, efficiency, and paper savings; the end result is generally to layer another set of reviews, delays, and paper chases over the problems involved, not solve them. It is also unfair and unrealistic to blame industry and contractors, or program managers, for finding ways to survive such "reforms" in a climate where program defense and a share of the budget is the goal, not program effectiveness. Unless cost containment and actual performance in executing the program

is made paramount, process-oriented reforms will never have much impact, and their potential value will remain disguised.

As has been said at the start of this analysis, the primary problem is a leadership problem and not a process problem. Once again, “fish rot from the head down.” Successive Secretaries and Deputy Secretaries of Defense had years in which to see every problem described in this paper coming. The same is true of successive Secretaries of the Air Force and Navy and Chiefs of Staff of the Air Force, Chief Naval Officers, and Commandants of the Marine Corps. No one needed better models, analysis, test and evaluation, cost analysis to predict that a broken procurement process would get worse. It did not take great management skill to see this would be compounded by QDRs and service strategies that did not establish clear force plans and procurement plans with credible and affordable long-term spending plans.

Unless each service Secretary, each service chief, and the top leadership of the office of the Secretary of Defense are held personally accountable for achieving cost containment and presenting credible procurement plans and program budgets to Congress on an annual basis, the problems in military aviation procurement will continue – along with similar problems in virtually every other aspect of defense procurement. It is also pointless to blame contractors, low and mid-level officers and officials, and Congress for their contribution to the problem until leadership and responsibility are enforced at the top.

## Notes

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- <sup>1</sup> National Journal, *The Bills Come Due*, 14 March 2008, cover story.
- <sup>2</sup> GAO, *Defense Acquisitions – Assessment of Selected Weapon Programs*, March 2008, pp. 85, 105, 167.
- <sup>3</sup> *Ibid.*, p. 85.
- <sup>4</sup> Unattributed industry source.
- <sup>5</sup> National Journal, *Aging Aircraft*, 14 March 2008, cover story.
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- <sup>7</sup> National Journal, *The Bills Come Due*, 14 March 2008, cover story.
- <sup>8</sup> National Journal, *Aging Aircraft*, 14 March 2008, cover story.
- <sup>9</sup> CRS, *F/A-22 Raptor*, RL31673, 6 January 2005, p. 1.
- <sup>10</sup> United States Air Force, *Committee Staff Procurement Backup Book – FY2009 Budget Estimates, Aircraft Procurement*, and *Staff Procurement Backup Book – FY1999 Budget Estimates, Aircraft Procurement, Air Force, Volume I*, February 1998, Exhibit P-40, p. 24
- <sup>11</sup> Unattributed industry source.
- <sup>12</sup> National Journal, *Aging Aircraft*, 14 March 2008, cover story.
- <sup>13</sup> *Ibid.*
- <sup>14</sup> *Ibid.*
- <sup>15</sup> Loren B. Thompson, *Air Force Struggles To Meet Airlift Needs Of Joint Force*, Washington, DC: The Lexington Institute, Issue Brief, 4 December 2007.
- <sup>16</sup> CRS, *Air Force Air Refueling: The KC-X Aircraft Acquisition Program*, 4 March 2008.
- <sup>17</sup> Stephen Manning, “Air Force Official Looks To '09 Tanker Bid,” *Associated Press*, 16 September 2008.
- <sup>18</sup> *Ibid.*
- <sup>19</sup> GAO, *Defense Acquisitions – Assessment of Selected Weapon Programs*, March 2008, p. 106.
- <sup>20</sup> *Ibid.*
- <sup>21</sup> Unattributed industry source.
- <sup>22</sup> CBO, *The Long-Term Implications of Current Defense Plans*, March 2008, p. 26.
- <sup>23</sup> GAO, *Defense Acquisitions – Assessment of Selected Weapon Programs*, March 2008, p. 106.
- <sup>24</sup> Unattributed industry source.
- <sup>25</sup> Vago Muradian, “Navy Struggles With ‘Fighter Gap’,” *Defense News*, 7 April 2008.
- <sup>26</sup> Office of the Assistant Secretary of Defense (Public Affairs), *Fiscal 2009 Department of Defense Budget Release*, News Release No. 90-08, 4 February 2008.
- <sup>27</sup> National Journal, *Aging Aircraft*, 14 March 2008, cover story.
- <sup>28</sup> Unattributed industry source.
- <sup>29</sup> Unattributed industry source.
- <sup>30</sup> CRS, *F/A-22 Raptor*, RL31673, 6 January 2005, p. 2.
- <sup>31</sup> CRS, *F-22A Raptor*, RL31673, updated 13 August 2008, p. 2.
- <sup>32</sup> GAO, *Tactical Aircraft – Status of the F/A-22 and Joint Strike Fighter Programs*, GAO-04-597T, 25 March 2004, p. 12.
- <sup>33</sup> *Ibid.*
- <sup>34</sup> GAO, *Tactical Aircraft: DOD Should Present a New F-22A Business Case before Making Further Investment*, Letter to the Honorable C.W. Bill Young, Chairman of the Subcommittee on Defense Appropriations, House of Representatives, 20 Jun2 2006, p. 3.
- <sup>35</sup> United States Air Force, *Committee Staff Procurement Backup Book – FY2009 Budget Estimates, Aircraft Procurement, Air Force, Volume I*, February 2008, Exhibit P-40, p. 1-13.
- <sup>36</sup> Michael Hoffman, “F-22 Decision Delayed Until End of Bush Term,” *Defense News*, 10 June 2008.
- <sup>37</sup> Tom Shanker, “Gates Offers Assurances on Support for Air Force,” *New York Times*, 11 June 2008.
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- <sup>40</sup> GAO, *Tactical Aircraft: DOD Should Present a New F-22A Business Case before Making Further Investment*, Letter to the Honorable C.W. Bill Young, Chairman of the Subcommittee on Defense Appropriations, House of Representatives, 20 Jun2 2006, p. 3.
- <sup>41</sup> Loren Thompson, “Further F-22 Production Is Crucial To Winning Future Wars,” *The Lexington Institute Issue Brief*, 16 July, 2008.
- <sup>42</sup> Atlanta Journal-Constitution, *Air Force-Pentagon Impasse Threatens F-22*, 6 September 2008.

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<sup>43</sup> *Ibid.*

<sup>44</sup> Unattributed industry source.

<sup>45</sup> GAO, *Tactical Aircraft: DOD Should Present a New F-22A Business Case before Making Further Investments*, Letter to the Honorable C.W. Bill Young, Chairman of the Subcommittee on Defense Appropriations, House of Representatives, 20 June 2006, p. 5.

<sup>46</sup> *Ibid.*, p. 6.

<sup>47</sup> CRS, *F-22A Raptor*, RL31673, updated 13 August 2008, p. 7.

<sup>48</sup> GAO, *Defense Acquisitions – Assessment of Selected Weapon Programs*, March 2008, p. 85.

<sup>49</sup> CRS, *F-22A Raptor*, RL31673, updated 13 August 2008, p. 12.

<sup>50</sup> CRS, *Tactical Aircraft Modernization*, RL33543, Updated 11 August 2008, nt. 6.

<sup>51</sup> National Journal, *The Bills Come Due*, 14 March 2008, cover story.

<sup>52</sup> CBO, *The Long-Term Implications of Current Defense Plans*, March 2008, p. 20.

<sup>53</sup> CBO, *A Look at Tomorrow's Tactical Air Forces*, January 1997, pp. 83-87.

<sup>54</sup> GAO, *Defense Acquisitions – Assessment of Selected Weapon Programs*, March 2008, p. 105.

<sup>55</sup> *Ibid.*, p. 1-1.

<sup>56</sup> United States Air Force, *Committee Staff Procurement Backup Book – FY2009 Budget Estimates, Aircraft Procurement, Air Force, Volume I*, February 2008, Exhibit P-40, p. 1-13.

<sup>57</sup> GAO, *Defense Acquisitions*, GAO-08-467SP, March 2008, p. 105.

<sup>58</sup> CRS, *Navy-Marine Corps Strike-Fighter Shortfall*, RS22875, updated 1 August 2008, p. 3.

<sup>59</sup> Navy briefings to CRS, cited in CRS, *Navy-Marine Corps Strike-Fighter Shortfall*, RS22875, updated 1 August 2008, p. 3 and nt. 8.

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<sup>62</sup> Michael Sirak, "F-35 Nations on Track to Sign New MOU, Says JSF Program Office," *Defense Daily*, 20 November 2006.

<sup>63</sup> GAO, *Defense Acquisitions*, GAO-08-467SP, March 2008, p. 105.

<sup>64</sup> *Ibid.*, p. 106.

<sup>65</sup> Tony Capaccio, "United Technologies F-35 Engine Over Cost Estimate," *Bloomberg News*, 21 July 2008.

<sup>66</sup> *Ibid.*

<sup>67</sup> CRS, *F-35 Lightning II Joint Strike Fighter (JSF) Program*, RL30563, updated 29 August 2008, p. 4.

<sup>68</sup> CRS, *V-22 Osprey Tilt-Rotor Aircraft*, updated August 4, 2005, p. 2.

<sup>69</sup> Lee Gaillard, *V-22 Osprey: Wonder Weapon or Widow Maker?* Washington, DC: Center for Defense Information, 2006, p. 7.

<sup>70</sup> According to the Undersecretary of Defense's (Comptroller) FY2008/2009 Budget Estimates, the Air Force's variant comes at a unit cost of \$99 million in FY2008. The Navy variant is slightly less expensive at a unit cost of \$94 million in FY2008. See Undersecretary of Defense (Comptroller), United States Air Force Committee Staff Procurement Backup Book, FY2008/2009 Budget Estimates, February 2008, Exhibit P-40, p. 4-5, and Department of the Navy Fiscal Year 2009 Budget Estimates, February 2008, Exhibit P-40, p. 1.

<sup>71</sup> CRS, *V-22 Osprey Tilt-Rotor Aircraft*, updated August 4, 2005, p. 12-13.

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<sup>73</sup> *Ibid.*, p. 40.

<sup>74</sup> CRS, *V-22 Osprey Tilt-Rotor Aircraft*, updated August 4, 2005, p. 9.

<sup>75</sup> Mark Thompson, "Flying Shame," *Time*, 8 October 2007, p. 42.

<sup>76</sup> *Ibid.*

<sup>77</sup> *Ibid.*

<sup>78</sup> Lee Gaillard, *V-22 Osprey: Wonder Weapon or Widow Maker?* Washington, DC: Center for Defense Information, 2006, p. 7.

<sup>79</sup> Undersecretary of Defense (Comptroller), United States Air Force Committee Staff Procurement Backup Book, FY2008/2009 Budget Estimates, February 2008, Exhibit P-40, p. 4-5, and Department of the Navy Fiscal Year 2009 Budget Estimates, February 2008, Exhibit P-40, p. 1.

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- <sup>89</sup> *Ibid.*, p. 1.
- <sup>90</sup> *Ibid.*, p. 5.
- <sup>91</sup> Inside the Air Force, *USAF Looking To Buy Back Semi-Retired B-52 Stratofortress Bombers*, 3 October 2008.
- <sup>92</sup> Inside the Air Force, *USAF Looking To Buy Back Semi-Retired B-52 Stratofortress Bombers*, 3 October 2008.
- <sup>93</sup> Bruce Rolfsen, "B-2 Stealth Bombers Due for Upgrades," *Defense News*, 29 September 2008, p. 24.
- <sup>94</sup> John T. Bennett, "USAF Officials Offer Glimpse of Requirements for Long-Range Strike," *Inside The Air Force*, 10 February 2006.
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- <sup>105</sup> GAO, *Air Force Procurement – Aerial Refueling Tanker Protest*, GAO-08-991T, 10 July 2008, p. 2.
- <sup>106</sup> *Ibid.*, summary.
- <sup>107</sup> *Ibid.*, p. 4-8. Many of these conclusion have been challenged by the competitors. This summary exclusively reflects the views represented in the GAO's public report.
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- <sup>109</sup> Robert Gates in Dana Hedgpeth, "Pentagon Postpones Tanker Competition," *Washington Post*, 11 September 2008, p. D1/D2.
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