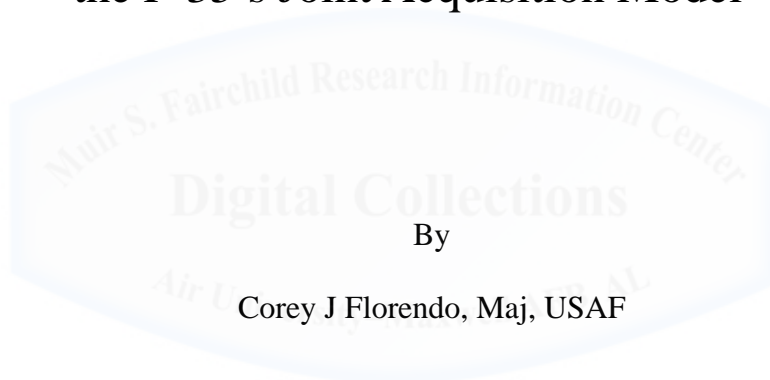


AIR COMMAND AND STAFF COLLEGE

AIR UNIVERSITY

JSF: Joint Strike Fighter or Just Simple Failure? Analyzing  
the F-35's Joint Acquisition Model



By

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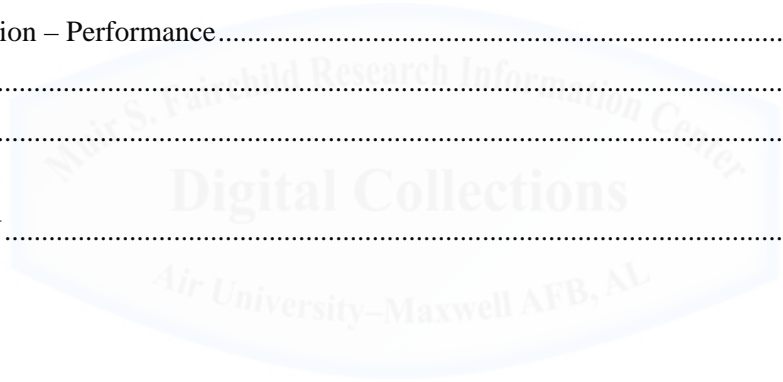
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## **Abstract**

The F-35 Joint Strike Fighter is America's fifth-generation replacement to nearly its entire fleet of fourth-generation aircraft. Until the F-35, individual branches of the Department of Defense acquired fighter aircraft separately, though after acquisition several fighter aircraft found themselves utilized by more than one branch of the military. This "traditional" acquisition model contrasts with the "joint" model used by the F-35, wherein the Air Force, Navy, and Marines all are involved in the acquisition of the aircraft, with their unique requirements incorporated into the design from day one. This paper analyzes how the joint acquisition model affected the costs, timeline, and performance of the F-35. The joint model failed to provide expected cost savings and resulted in performance trade-offs; however, it also prevented the taxpayer from having to fund the development of other, similar fighters for all the services, saved the time otherwise required to develop complex software, and created enough backers across the Department of Defense that it overcame the inevitable criticisms associated with large acquisition projects. With modifications to prevent the strict requirement for a high degree of common parts, the joint acquisition model is suitable for use on future acquisition projects.

## Introduction

When the United States recently celebrated the 100<sup>th</sup> anniversary of powered flight, it also marked its 100<sup>th</sup> anniversary of acquiring aircraft for the Department of Defense. In that time, the airplane transitioned from being a simple warfighting novelty to an integral part of the nation's defense. As its importance grew, every branch of the military adopted the airplane, and its numbers rapidly increased. The military grew to acquire what is currently five generations of fighter aircraft, with each generation seeing a progressively higher cost and a lower number of total aircraft. With each branch of the military requiring different capabilities for its fighter aircraft, the Air Force, the Navy, and eventually the Marine Corps all generally acquired fighters within their own services. For example, the P-47 and eventually the P-51 were the mainstay land-based fighters during World War II, while the F4U Corsair and the F6F Hellcat saw the largest action off of naval carriers during that time. The F-86 Sabre gained its legendary history in the Korean War flying off of land-based airfields, while the Navy used the FJ-2 and several other fighters optimized for flight off of aircraft carriers. While the Vietnam War saw the Air Force and Navy both sharing the F-4, albeit each with their own variants specialized for the particular needs of each service, by the Gulf War the Navy, Marines and Air Force had again acquired and fielded different aircraft for their respective services, although admittedly both the Navy and Marines flew the F-18. As the Department of Defense prepared to acquire a fifth-generation fighter aircraft, it was facing a long tradition and precedent of having aircraft that were acquired specifically by each branch.

As America's defense leaders drew up plans for its fifth generation fighter meant to replace the vast majority of fourth-generation aircraft, they faced a grim reality. The cost of fighter

aircraft had been rising at an exponential rate, and an analysis of the required replacement aircraft for its fourth-generation fleet yielded the requirement for an unprecedented budget.<sup>1</sup> The last fighter aircraft acquired, the F-22, had faced scathing criticism due to its substantial budget overruns,<sup>2</sup> and the Army was one of several branches to have an aircraft program cut due to similar cost runaways.<sup>3</sup> With the Cold War over and austere defense budgets a new reality, use the traditional acquisition model and procuring separate aircraft for each individual branch exposed each program to similar threats of reductions or altogether cancellations.

In an effort to quell the rising costs associated with new aircraft, the Department of Defense decided to modify the acquisition model that it had previously used. As opposed to acquiring a fighter aircraft unique to each branch of the military, the DoD asked for a single aircraft that could fulfill the missions of the Air Force, Navy, and Marines. In doing so, the DoD was hoping to save on the sizable development and operating costs that are associated with every new aircraft.<sup>4</sup> Each service, however, had different needs for their aircraft. Air Force airplanes need to be able to perform, among other missions, offensive counter-air, defensive counter-air, close air support, suppression of enemy air defense, and air interdiction missions. Navy aircraft need to be able takeoff and land on a carrier and be reliable enough for sustained operations without a suitable landing base within hundreds of miles. The most unique requirement, however, does not belong to the Air Force or Navy. The Marines require that their next-generation fighter be able to

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<sup>1</sup>General Accounting Office, *Operating and Support Costs of New Weapons Systems Compared to Their Predecessors*, Report to the Senate Subcommittee on Appropriations by the Comptroller General of the United States, United States General Accounting Office, 17 October 1977.

<sup>2</sup> Goozner, Michael, *GAO Finds Major Defense Department Cost Overruns*, The Fiscal Times, 29 Mar 2011. <http://www.thefiscaltimes.com/Blogs/Gooz-News/2011/03/29/Gooz-News-GAO-Finds-Major-Defense-Department-Cost-Overruns>

<sup>3</sup> Government Accountability Office, *Cancelled DOD Programs--DOD Needs to Better Use Available Guidance and Manage Reusable Assets*, Report to Congressional Committees, March 2014.

<sup>4</sup> Carey, Bill, *Lockheed Martin Follows 'Blueprints' to Drive Down F-35 Costs*, Aviation International News, 12 June 2015. <http://www.ainonline.com/aviation-news/business-aviation/2015-06-12/lockheed-martin-follows-blueprint-drive-down-f-35-costs>

takeoff in a very short distance and land vertically. Combining all of those competing requests can be likened to attempting to design a car that can go from 0 to 60mph in 4 seconds, has 6 seats, gets 35 miles per gallon, and can tow 5,000 pounds worth of cargo. Meeting the requirements of all the services in one airframe would require significant design tradeoffs.

In asking for the aircraft that eventually became the F-35, the US government asked for a lot, and it knew that trade-offs were inevitable. It did not make this request out of ignorance, there were significant cost savings and efficiencies in mind. Over 20 years past that initial decision, and despite the fact that the F-35 has not yet reached operational capability, it is time to examine that decision to acquire one aircraft for three DoD services. This paper will explain the “traditional” versus “joint” acquisition models and evaluate the F-35’s joint acquisition model by examining the program’s cost, timeline, and performance. It will analyze the advantages and disadvantages realized by the joint model before recommending a path forward for future fighter acquisitions.

## **Background**

The Department of Defense did not have a solid, repeatable, and well-defined process for acquiring new aircraft before the F-35. Almost every aircraft acquired by the DoD had unique requirements or considerations that made some aspect of its acquisition unique. For example, the F-22 was the first stealth fighter, the F-16 was envisioned as a day VFR defense fighter and a counterpart to the F-15, and the F-4 was originally designed and acquired by the Navy before being pushed to all branches of the military by Defense Secretary Robert McNamara.<sup>5</sup> However,

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<sup>5</sup> Paul St. John Turner. *Profiles in Aircraft, Volume 9, McDonnell Douglas F-4 Phantom*. Garden City, New York: Doubleday & Company, Inc. 1971.

all previous fighter aircraft (including the F-4) were initially acquired by one branch of the military before being adopted by other branches. Despite those acquisition processes having stark differences, they can all be called “traditional” acquisition methods in that they did not have all three services combined from the outset to develop a fighter that met the requirements of all stakeholders. The F-35 is a stark departure from that traditional acquisition model. With buy-in from all services before the first dollar was spent, the “joint” acquisition model is the first to specifically try to address the vastly different requirements of three different DoD branches in one aircraft. Henceforth, this paper will refer to the F-35’s acquisition model as the “joint” acquisition model and the previous model, wherein one branch of the military primarily ran the acquisition and development of a fighter, as the “traditional” model. Note that this nomenclature is used only for convenience, and it is acknowledged that stark differences exist in the processes used to acquire the various types of aircraft all included under the “traditional acquisition model” umbrella.

## **Evaluation Criteria**

Of the many ways to judge the performance of an acquisition program, cost is one of the most effective, and therefore one of the most common. The budget for the F-35 program, like all large acquisition programs, is comprised of four major parts: the research and development costs, the investment cost, the operating/support cost, and the disposal cost.<sup>6</sup> This paper will analyze the joint acquisition model’s effect on those four types of cost. The F-35’s research and development costs, which account for approximately 15% of the total program costs, occurred early in the program and are the costs associated with developing the technology involved with

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<sup>6</sup> Defense Acquisition University, Defense Acquisition Guidebook, Fort Belvoir, Virginia, 2015.

the aircraft.<sup>7</sup> The investment costs (known in some circles as procurement costs), which are approximately 25% of the total cost, are the initial costs required for the actual production of the F-35s, such as the tooling and machinery, the raw materials, and so forth.<sup>8</sup> The operating and support costs, constituting approximately 50% of the program's total cost, are the costs associated with using the F-35 throughout its design life.<sup>9</sup> Finally, the disposals costs are just that—the costs associated with the removal of the F-35 once it has lived out its useful life.<sup>10</sup> This paper will look at the budget of the F-35 program in terms of the above cost types, with the exception of disposal costs, which cannot be judged this early in the program.

When not looking at the dollars and cents, a program's ability to stay within the originally-prescribed timeline can be an effective measure of its efficiency. Though delays can be caused by factors nearly out of the control of a program's management, a program that executes without schedule overruns can generally be described as more effective than a program struggling through several slips. This paper will look at the timeline of the F-35 and evaluate how requirements stemming from the joint acquisition model have contributed to its timeline. It will also compare the ability of the F-35 to stay on schedule to that of both the F-22 (a recently-acquired fighter) and the F-16 (a program acquired approximately 40 years ago).

Though one of the most subjective, a comparison of an aircraft's abilities when compared to its peers is an effective measure of an acquisition program's performance. A program that was forced to make compromises in order to adhere to cost or schedule constraints will not boast significant leaps in capabilities; likewise, a program that was under budget and ahead of schedule

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<sup>7</sup>Defense Acquisition University, Defense Acquisition Guidebook, Fort Belvoir, Virginia, 2015.

<sup>8</sup> Ibid.

<sup>9</sup> Ibid.

<sup>10</sup> Ibid.

likely would have had sufficient resources to research, develop, test, and field advanced capabilities. For example, when the C-17 first became operational and started to replace the C-141 as a transport aircraft, its capability (as measured via a metric used by Air Mobility Command) was almost 40% below its requirement.<sup>11</sup> The C-17's lack of performance was accompanied by a significant budget overrun (original plan was to pay \$41.8B for 210 aircraft, follow-on plans increased the total cost and halved the number of aircraft acquired) and schedule delays.<sup>12</sup> It is easy to conclude that the government and Department of Defense accepted a “good enough” product from the contractor for the C-17 instead of enduring more delays and budget overruns. Similarly, the F-18 met all performance requirements set for it, along with all budget and schedule constraints.<sup>13</sup> This paper will examine both the unclassified qualitative performance metrics of the F-35 and the qualitative performance, as determined by its developmental and operational test pilots. The analysis will attempt to determine what, if any, trade-offs in performance were made as a result of the joint acquisition model, and whether those trade-offs were “worth it” in terms of cost and schedule savings. In other words, this paper will examine what each of the services are getting in terms of performance with respect to their respective needs, and whether those services are satisfied with that performance.

### **Results of Evaluation – Cost**

The cost of the F-35 program has risen steadily since its inception. Currently the program's research and development costs are estimated at approximately \$55.2B, which is a 60% increase

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<sup>11</sup> Government Accountability Office, Military Readiness Air Transport Capability Falls Short of Requirements, Government Accountability Office, Washington, D.C., June 2000.

<sup>12</sup> Government Accountability Office, Status of of the C-17 Development Program, Government Accountability Office, Washington, D.C., March 1993.

<sup>13</sup> General Accounting Office, Need to Demonstrate F-18 Naval Strike Fighter Weapon System Effectiveness Before Large-Scale Production, Comptroller General Report to Congress, Feb 1979.

from the initial limit of \$34.4B.<sup>14</sup> The F-35's procurement costs have ballooned even more, with a 71% increase from its inception limit of \$196.6B to over \$330B.<sup>15</sup> In just two of the four types of program costs, the F-35 has been closer to doubling its initial budget than staying within it. The overages in just those two categories—the only two categories for which the program can be accurately judged at this stage—would be enough to build 12 of the Navy's newest aircraft carriers!<sup>16</sup> The program's initial goal was to produce an affordable yet highly capable fighter for use by the United States and its allies. The F-35 even had—and technically still has—the lofty initial goal of costing less per unit than any of the aircraft it is replacing.<sup>17</sup> Considering that the F-35's joint acquisition model was enacted primarily to reduce the cost of the program, it would appear from the budget numbers stated above that, at least at first glance, joint the endeavor was an utter failure.

Initial budget figures for the F-35 aside, budget overruns are not unique to the F-35 program, and costs for new aircraft have increased exponentially faster than can be explained by inflation. For example, the F-22 is the last aircraft procured by the Department of Defense, and as the nation's only other fifth-generation fighter with similar capabilities to the F-35, it is a fitting aircraft to compare with the F-35. During its development and initial fielding the F-22 was subject to intense criticism, some of which was directed squarely at its cost, which also raced past its initial limit by over 70%.<sup>18</sup> Notably, the F-22 program's cost overruns and concerns over

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<sup>14</sup> Government Accountability Office, F-35 Joint Strike Fighter: Current Outlook Is Improved, but Long-Term Affordability is a Major Concern, Report to Congressional Committees, March 2013.

<sup>15</sup> Sullivan, Michael J. F-35 Joint Strike Fighter Observations on Program Progress, Statement to Congressional Subcommittee on Tactical Air and Land Forces, April, 2015.

<sup>16</sup> Shalal-esa, Andrea. "US Navy Pledges Cost Cuts as it Christens New Aircraft Carrier," Reuters, 5 Nov 2013. <http://www.reuters.com/article/us-usa-navy-carrier-idUSBRE9A413E20131105>

<sup>17</sup> Clark, Colin. "Lockheed Boasts 'F-35 Will Cost Less Than any 4<sup>th</sup>-Gen Fighter,'" Breaking Defense, 17 Dec 2013. <http://breakingdefense.com/2013/12/lockheed-boasts-f-35-will-cost-less-than-any-4th-gen-fighter/>

<sup>18</sup> Li, Allen, Impact of F-22 Production Cost Reduction Plans on Cost Estimates Testimony, General Accounting Office, 2 Aug 2001.

its budget eventually caused the Air Force to lower its procurement order from 381 to 183 aircraft.<sup>19</sup> A review of the archived documents from the F-22 program yield many of the same phrases that are now rampant in the F-35 program: testimony decrying that the program not worth the money, claims that a better use of resources would be to acquire more of the fourth-generation fighters that the F-22 was intended to replace, and threats to cancel the program. Going further back to the previous generation of fighters, the F-16's cost increased approximately 55% over its initial limit.<sup>20</sup> The F-15 also went over its initial budgetary constraints by approximately 50%.<sup>21</sup> The F-16 is the fourth-generation version of the F-35—both aircraft are multi-role, built for export, and not specifically designed for air superiority. While the F-35 is designed to partner with the F-22 to gain air superiority, the F-16 is designed to partner with the F-15, which was procured slightly before the F-16 (just as the F-22 was procured slightly before the F-35). Looking at the Navy's aircraft procurement, it is apparent that cost overruns are not unique to the Air Force, since the F-18, which was acquired a few years after the F-16, also experienced cost overruns of approximately 50% the original budget.<sup>22</sup> Finally, it is prudent to examine an aircraft from the transport fleet, to determine whether the budget problems are unique to fighter aircraft. The C-17 is the Air Force's most recently acquired transport aircraft; the program started slightly before the F-22 and ran mostly concurrent with it. The C-17 was also no stranger to controversy—it suffered from setbacks in testing, was over budget, and behind schedule.<sup>23</sup> The Air Force eventually received just over half of the aircraft originally

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<sup>19</sup> Young, Bill. "Tactical Aircraft: DOD Should Present a New F-22A Business Case before Making Further Investments," Letter to Defense Subcommittee on Appropriations, 20 June 2006.

<sup>20</sup> General Accounting Office, Status of the F-16 Aircraft Program, Report to Congress, April 1977.

<sup>21</sup> Stolarow, J.H. "Air Force Should Recover Excess Costs of Prior F-15 Contracts and Take Action to Save Costs on Future F-15 Contracts," Letter to Secretary of Defense, October 1979.

<sup>22</sup> General Accounting Office, Need to Demonstrate F-18 Naval Strike Fighter Weapon System Effectiveness Before Large-Scale Production, Comptroller General Report to Congress, Feb 1979.

<sup>23</sup> Vartabedian, Ralph. "Air Force Takes Delivery of Troubled C-17 Cargo Jet," Los Angeles Times, 15 June 1993.

contracted (120 instead of 210), but at a cost that was almost 50% above the original budget; eventually the budget of the program totaled approximately 50% more than its original limit.<sup>24</sup>

While the F-35 program is currently well over its initial budget, almost every other fighter aircraft has also experienced budget overruns. Those overruns increase with time, with the latest aircraft procured (the F-35) experiencing the highest percentage overrun. Although the F-35 is neither at full rate production nor operational, the most recent cost estimates for the program have shown a slight decrease in the overall budget.<sup>25</sup> Although the F-35 has not yet shown even a decrease in the alarming trend of budget overruns, it did approximately mirror the budget exceedances of the F-22. It may not have reversed the trend, but the F-35 also did not exacerbate the budget problem that has plagued every aircraft in the past half-decade.

The F-35 is not simply replacing the Air Force's fourth generation fighters. The F-35 will eventually replace the F-18s in the Navy and Marine Corps, as well as the AV-8Bs that are also in the Marines. If the F-35 were to not be a joint venture, the Navy and Marines would also be forced to develop their own replacements, meaning that the US taxpayer would end up stuck with a bill for not only the Air Force's F-35s, but also the aircraft acquired by its sister services for the purpose of replacing their aging aircraft. While the budget overruns of the F-35 may appear to be grossly excessive, when considering that the program encapsulates the costs that would otherwise be billed by other services, the exceedances do not appear to be so egregious.

All of the aircraft discussed before were not acquired via the joint process of the F-35. Of the four types of costs associated with an acquisition program, a large percentage of the savings

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<sup>24</sup> Congressional Budget Office, "The C-17: Costs and Alternatives," Congressional Budget Office, Washington D.C., August 1993.

<sup>25</sup> Government Accountability Office, F-35 Joint Strike Fighter: Current Outlook Is Improved, but Long-Term Affordability is a Major Concern, Report to Congressional Committees, March 2013.

planned from the F-35's joint acquisition model are expected to be realized in the operating costs of the aircraft. The operating costs alone constitute the vast majority of the budget for a program, so even a minor savings in this area would have much greater effect than in any other area. With a large percentage of the aircraft's required tooling, parts, and support equipment similar across all three aircraft variants, that support equipment can be acquired in mass quantities and therefore at a lower cost than would otherwise be available if it were specific to each aircraft. Furthermore, maintenance on aircraft components can be performed at depot centers and repair facilities that do not have to be specifically constructed for different types of aircraft, which reduces the support costs. Such cost-saving measures have been suggested on previous programs; for example, cost-saving measures proposed to the F-18 program included using test equipment that could be used on multiple aircraft types, consolidating avionics repair and depot maintenance facilities, and eliminating extraneous maintenance centers.<sup>26</sup> If such savings were suggested on just one aircraft that was acquired by a specific service, the potential savings could be escalated if enacted on a scale that includes the Air Force, Navy, and Marines.

According to latest estimates, the operating and support costs of the F-35 are expected to amount to \$19.9B per year in 2010 dollars once the aircraft is at operational capability.<sup>27</sup> This is in comparison the combined operating and support costs of \$11.1B for all F-15C/D, F-16, AV-8B, and F/A-18 aircraft, which accounts for the vast majority of the aircraft the F-35 is intended to replace.<sup>28</sup> This increase in operating costs contradicts the explicit purpose of the F-35's joint acquisition model. It also contradicts historical precedent, wherein previous generations of

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<sup>26</sup> United States Comptroller General, Operational and Support Costs of the Navy's F/A-18 Can Be Substantially Reduced, General Accounting Office, June 1980.

<sup>27</sup> Government Accountability Office, F-35 Sustainment, Need for Affordable Strategy, Greater Attention to Risks, and Improved Cost Estimates, Report to Committee on Armed Services, September 2014.

<sup>28</sup> Ibid

aircraft were generally less expensive to operate than their predecessors. For example, the F-15, F-16, and F-18 all were acquired via traditional acquisition models to replace the F-4. The F-16's initial operating and support costs were \$16.4M per squadron, compared to \$22.9M for the F-4.<sup>29</sup> This represents a 28% decrease in cost. The F-15 also replaced the F-4, and the F-15 cost 4% more to operate than the F-4. Finally, the F-18 cost 26% less to operate than the F-4. So while the F-35 and its joint acquisition model is projected to cost close to double what it costs to operate its predecessors, those same predecessors were able to maintain or even decrease their operating costs when compared to the aircraft they replaced.

The F-35 incorporated a joint acquisition model in an attempt to lower the costs of acquisition. The taxpayer instead is stuck footing a bill higher than any previous precedent set for it. That fact begs one to ask whether or not the F-35's joint acquisition model somehow caused a higher cost to the program. Despite the affordable goals of the F-35 program, the F-35 is still a stealth aircraft, meaning that special maintenance and sustainment procedures are necessary in order to keep the aircraft's low observability. Therefore, the best way to determine whether the F-35's joint model caused a higher price tag is to compare the F-35's cost to that of the F-22, which is another stealthy fighter and therefore subject to maintainability concerns similar to the F-35. A direct comparison of the F-35 and F-22 price tags tells a different story than when comparing the F-35 to the aircraft it is directly replacing. The per-plane cost of the F-22, which is the total cost of the program divided by the number of aircraft, is approximately \$412M, which is a 176% increase from its original estimate of \$149M.<sup>30</sup> The per-plane cost of the F-35 is currently

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<sup>29</sup> General Accounting Office, *Operating and Support Costs of New Weapons Systems Compared With Their Predecessors*, Report to the Senate Committee on Appropriations by the Comptroller General of the United States, October, 1977.

<sup>30</sup> Vartabedian, Ralph and Hennigan, W.J., *F-22 Program Produces few Planes, Soaring Costs*, Los Angeles Times, 16 June 2013. <http://touch.latimes.com/#section/-1/article/p2p-76307901/>

estimated to be \$161M, which is approximately a 100% increase from the plane's \$81M budget per plane at the onset in 2001.<sup>31</sup> The lower per-price cost of the F-35 is primarily due to the fact that there are over 2,000 F-35s planned, while the F-22 production was limited to 196 aircraft.<sup>32</sup> Therefore, the four types of costs inherent to the F-35 program are divided over more than 10 times as many aircraft as the F-22. Simply increasing the number of airplanes built does not decrease the cost per plane as much as might be expected because the procurement cost of each new plane, such as the raw materials, tools, and man-hours required for construction, must still be paid for. It is no wonder why many observers are noting that the joint acquisition model may not have saved the program any money at all.<sup>33</sup> Though the F-35's joint acquisition model did not make the plane as affordable as those it is to replace, evidence also shows that it did not increase the cost of the program.

Examining the costs of the largest acquisition program in the history of the United States is not simple, and there are no straightforward conclusions. Regardless, the F-35 undoubtedly exceeded its initial cost estimates, and those budget overruns are generally greater than experienced in previous programs. Even though the joint acquisition model is supposed to cut down on the operation and support costs of the aircraft, current estimates are that the aircraft will be almost twice as expensive to fly and maintain as the aircraft it is replacing. The F-35 costs less per aircraft than the F-22, thanks mainly to the large aircraft order of the F-35. This large aircraft order is the result of the joint acquisition model. If the F-35 were only to be acquired by one service and not via the joint model, nearly all of the research and development costs, along with

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<sup>31</sup> Vartabedian, Ralph and Hennigan, W.J., *F-35 Jet Struggles to Take Off*, Los Angeles Times, 12 June 2013. <http://touch.latimes.com/#section/-1/article/p2p-76266294/>

<sup>32</sup> Axe, David, *Buyer's Remorse: How Much has the F-22 Really Cost?* Wired, 14 Dec 2011.

<sup>33</sup> Capaccio, Tony. *Lockheed F-35 Bad Deal as One Jet for All*, RAND Reports, Bloomberg Business, 18 Dec 2013. <http://www.bloomberg.com/news/articles/2013-12-17/lockheed-f-35-bad-deal-as-one-jet-for-all-report-finds>

some of the operational support costs, would have been recreated in a different form in order to support the Navy and/or Marines' fifth-generation replacement fighter to the F/A-18 and the A/V-8B, meaning the US taxpayer would be stuck with a much larger bill in the end, although each program would have appeared to have a smaller individual cost. As an idea of the additional costs saved by the joint model, the F-22's research and development budget was approximately \$19B,<sup>34</sup> while the F-35's developmental budget is significantly higher at nearly \$55B.<sup>35</sup> After a thorough analysis of the costs associated with both the F-35 and previous programs, it is apparent that the joint acquisition model did not successfully keep the program within its initial budgetary limitations; however, when considering the development and support costs of the program that would be duplicated in other, similar, traditionally-acquired programs, the overall cost to the US taxpayer is lower when using the joint acquisition model.

There is one last benefit—at least it *can* be viewed as a benefit—of the joint acquisition model regarding costs. With the Air Force, Navy, and Marines all carrying vested interests in the program, it becomes much more difficult to cancel, regardless of budget overruns. With three programs running, cancelling one would leave the other two services with viable replacements for their aging fleet of aircraft. When three services combine, the program becomes, in a way, almost too big to fail. The past is littered with examples of failed acquisition programs, and almost all of them used the traditional, single-service model. The DoD cancelled the Army's Comanche helicopter program in 2004 after its contract price of \$6.6B had been more than doubly exceeded, with a final program cost of over \$15B.<sup>36</sup> The Marines worked to develop the

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<sup>34</sup> General Accounting Office, Progress in Meeting F-22 Cost and Schedule Goals, Testimony Before Committee on Government Reform, House of Representatives, December 1999.

<sup>35</sup> Government Accountability Office, F-35 Joint Strike Fighter Observations on Program Progress, April 2015.

<sup>36</sup> Government Accountability Office, Cancelled DOD Programs--DOD Needs to Better Use Available Guidance and Manage Reusable Assets, Report to Congressional Committees, March 2014.

VH-71, a replacement for the presidential helicopter; however, the DoD also terminated that program in 2009 when the eventual cost estimates more than doubled the initial budget.<sup>37</sup> On a larger financial scale, the Army's Future Combat System had an estimated overall budget of \$159B until it was cancelled due to budget overruns and technology failures.<sup>38</sup> A review of many cancelled programs reveals that almost all programs that faced cancellation had budgets that nearly doubled and technology that underperformed. While doubling a budget is by no means grounds for an automatic cancellation—there are also plenty of programs that more than exceeded initial budgets without getting the axe—it does seem to be a major criteria. The F-22, like the F-35, faced blistering scrutiny for soaring costs and disappointing early performance.<sup>39</sup> As a result of those criticisms and budget overruns, the F-22 program was terminated at 187 aircraft, which is just over half the original order and almost 100 less aircraft than the Air Force stated as its minimum required number.<sup>40</sup> The F-35 has certainly faced many calls for its cancellation—calls that are based largely upon the budget numbers discussed above and partly upon the performance and timeline that will be discussed below. Through those calls and criticisms, the F-35 has trudged on, and the Marine Corps—which was the program's priority due to its need to replace its fleet of older AV-8Bs and F/A-18s—declared initial operational capability with the F-35B in July of 2015.<sup>41</sup> Though the F-35 will continue to face well-founded criticism and it will inevitably face many more challenges, it has now gained so much momentum, with so much buy-in from so various services, that it will continue toward fielding,

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<sup>37</sup>Government Accountability Office, *Cancelled DOD Programs--DOD Needs to Better Use Available Guidance and Manage Reusable Assets*, Report to Congressional Committees, March 2014.

<sup>38</sup> *Ibid.*

<sup>39</sup> Ferran, Lee, *Report: F-22 Loses \$79 Billion Advantage in Dogfights*, ABC News, 30 July 2012.

<http://abcnews.go.com/blogs/headlines/2012/07/f-22-fighter-loses-79-billion-advantage-in-dogfights-report/>

<sup>40</sup> Gertler, Jeremiah, *Air Force F-22 Fighter Program*, Congressional Research Service Report for Congress, 11 July 2013.

<sup>41</sup> Rosen, Armin and Macias, Amanda, *This is What Regret Looks Like for the Pentagon*, Yahoo! Finance, 1 Feb 2016. <http://finance.yahoo.com/news/regret-looks-pentagon-032341164.html>

if for no other reason than the strong interests created in it across the DoD by its joint acquisition model.

### **Results of Evaluation – Timeline**

The F-35 program and its joint acquisition model started development in October of 2001.<sup>42</sup> The F-35 was initially slated to achieve initial operational capability (IOC)—the declared state at which a weapons system is ready for combat, though perhaps missing certain capabilities—in 2010.<sup>43</sup> By 2003, IOC had already slipped to 2012. In 2007, multiple delays in the program resulted in a new baseline for the budget and timeline with an IOC deadline between 2012 and 2015 and full-rate production in 2013. After several more delays, the F-35B reached IOC in July of 2015.<sup>44</sup> The F-35A and F-35C both have yet to reach IOC, and full-rate production is planned for 2019.<sup>45</sup> A program that was originally supposed to take 10 years from start of development to full-rate production may now very well double that time—a fact that is fitting when considering that, as described above, the costs for the program are also approximately double the original estimate. Clearly the F-35 has had timeline difficulties; the question is whether those difficulties can be attributed to its joint acquisition model.

The F-35 is not the first acquisition program to fall drastically behind timeline. The F-22 took approximately twice as long as initially planned to achieve full-rate production.<sup>46</sup> The B-2

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<sup>42</sup> Government Accountability Office, F-35 Joint Strike Fighter: DOD Actions Needed to Further Enhance Restructuring and Address Affordability Risks, Report to Congressional Committees, June 2012.

<sup>43</sup> Ibid.

<sup>44</sup> Rosen, Armin and Macias, Amanda, *This is What Regret Looks Like for the Pentagon*, Yahoo! Finance, 1 Feb 2016. <http://finance.yahoo.com/news/regret-looks-pentagon-032341164.html>

<sup>45</sup> Government Accountability Office, F-35 Joint Strike Fighter: DOD Actions Needed to Further Enhance Restructuring and Address Affordability Risks, Report to Congressional Committees, June 2012.

<sup>46</sup> General Accounting Office. F-22 Development and Testing Delays Indicate Need for Limit on Low-Rate Production, Report to Congressional Committee, March 2001.

program took approximately 50% longer than initially planned; however, that delay was due in large part to the Air Force's decision to change the requirements for the aircraft after a design had been finalized.<sup>47</sup> Scanning further back, almost every fighter acquired over the past 50 years seems to have been plagued with some sort of delay, though none were as large as the delays seen by the F-22 and F-35.<sup>48</sup> While any acquisition program will initially provide their most optimistic estimate for a timeline and therefore can face some acceptable delays, the F-35 and F-22 program slips seem to be almost an order of magnitude higher than previously faced, leading one to wonder if there is something new about those aircraft causing larger-than-normal delays.

One thing is becoming more and more evident with fighter acquisition: software will drive the timeline more than anything else. The F-35's complex software remains the most troublesome part of the program with regards to the schedule.<sup>49</sup> Looking back, the F-22's schedule delay had multiple causes, including similar software issues, inefficient flight test and assembly problems.<sup>50</sup> Regarding the software issues, it is notable that the F-22 and the F-35 are the only two "fifth-generation" fighters the US has procured, and they are the only fighters that incorporate data "fusion" to the pilot. This "fusion" incorporates information that previously was available to the pilot in different forms and combines it into one display. A modern fighter aircraft has multiple sensors and uses all of them to gain a picture of the battlefield. While legacy fighters simply presented the information in a federated, but not fused, fashion to the pilot on multiple scopes and displays, the F-22 and F-35 combine this information on one display. Trying

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<sup>47</sup> Conahan, Frank C. Status of the B-2 Bomber Program. United States General Accounting Office Testimony to House Committee on Armed Services. 22 Feb 1990.

<sup>48</sup> General Accounting Office, Status and Cost of Air Force Fighter Procurement, Report to the Chairman, Committee on Armed Services, House of Representatives, April 1987.

<sup>49</sup> Government Accountability Office, F-35 Joint Strike Fighter Problems Completing Software Testing May Hinder Delivery of Expected Warfighting Capabilities, Report to Congressional Committees, March 2014.

<sup>50</sup> General Accounting Office, F-22 Delays Indicate Initial Production Rates Should be Lower to Reduce Risks, Report to Congressional Committees, March 2002.

to define the intricacies of how to gain battlefield situational awareness is simply not an easy task, and that was the reason for the avionics delays in the F-22 program. While one would initially assume that if this problem were solved on the F-22 that those solutions would translate to the F-35, Boeing manufactured the F-22's avionics and data fusion suite, while Lockheed is developing that product for the F-35.<sup>51</sup> The proprietary nature of the software means that traits from one aircraft cannot be transferred directly to another, even though the F-22 has evolved far enough to have a solution to this problem. Also, although specifics are classified, the F-35 is newer and therefore can be assumed to be more advanced than the F-22, meaning that even if software could be transferred, it would have to incorporate newer and presumably more sensitive technology. The F-35's software incorporates 24 million lines of code.<sup>52</sup> Compared to the 1.7 million lines of code in the F-22,<sup>53</sup> the F-35 has an enormous amount of code inherent to it, meaning that there is an enormous amount of testing to be done on that code. When problems are found they must be fixed, and then the software must be checked not only for fixes to that software but also to see if other features not intended to be touched were in fact affected. This software would be on the jet and would require extensive testing regardless of whether it was acquired traditionally or jointly. Therefore, the software delays cannot be attributed to the joint acquisition model of the F-35.

Though the F-35's software delays would have occurred regardless of the acquisition model used, the program also experienced delays relating to the F-35B that are a direct result of the

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<sup>51</sup> Majumdar, David. *What if America Had Selected the X-32 Over the F-35 Stealth Fighter?* The National Interest, 1 Dec 2015. <http://www.nationalinterest.org/blog/the-buzz/what-if-america-had-selected-the-x-32-over-the-f-35-stealth-14477>

<sup>52</sup> Government Accountability Office, *F-35 Joint Strike Fighter: DOD Actions Needed to Further Enhance Restructuring and Address Affordability Risks*, Report to Congressional Committees, June 2012.

<sup>53</sup> Global Security, *F-22 Raptor Avionics*, GlobalSecurity.Org. <http://www.globalsecurity.org/military/systems/aircraft/f-22-avionics.htm>

joint acquisition model. The F-35B is the Marine Corp variant that is designed to take off and land in very short distances. In January of 2011, Defense Secretary Robert Gates placed the F-35B on “probation” due to “significant testing problems” and recommended its cancellation if the problems could not be rectified within two years.<sup>54</sup> This “probation” period likely saved the F-35B from outright cancellation due to pleading by the Marine Commandant to keep the program afloat.<sup>55</sup> The probationary period ended a year later after improvements were shown in five areas of the F-35B, all of which focused on the F-35B’s unique ability to take off and land in short distances.<sup>56</sup> After the probationary period was lifted, the F-35 test team focused on the F-35B in order to complete its testing prior to its desired IOC date in 2015. As the F-35B approached IOC, the limiting factor was not the testing of its design improvements after its probationary period; rather, the aforementioned software testing drove the timeline.<sup>57</sup> Therefore, even though the F-35B hardware and aircraft testing was delayed by approximately a year to address shortcomings, the overall timeline was still driven by the aircraft’s software development, testing, and fielding.

The F-35 program is drastically behind its original timeline. Though various factors play into the scheduling setbacks, the overarching root cause is the necessary development and testing of the complex software utilized by the aircraft. This software drives the unique capabilities of fifth-generation aircraft and would not be mitigated by a traditional acquisition model. Though utilizing the developed software of the F-22 as a baseline would likely have reduced the delays in

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<sup>54</sup> Sweetman, Bill. *F-35B Put on Probation, New Bomber to go Forward*. Aviation Week, 6 Jan 2011. <http://aviationweek.com/awin/f-35b-put-probation-new-bomber-go-forward-0>

<sup>55</sup> Ibid.

<sup>56</sup> Butler, Amy. *Panetta Lifts F-35B Probation*. Aviation Week, 20 Jan 2012. <http://aviationweek.com/defense/panetta-lifts-f-35b-probation>

<sup>57</sup> Government Accountability Office, *F-35 Joint Strike Fighter: DOD Actions Needed to Further Enhance Restructuring and Address Affordability Risks*, Report to Congressional Committees, June 2012.

the F-35 program, that was disallowed due to proprietary concerns that would also be in play regardless of the acquisition model used. Though the delays in the F-35 program are frustrating, they were not caused by the program's joint acquisition model.

## **Results of Evaluation – Performance**

The budget and timeline of a program are unclassified and well-publicized figures that are readily used as a litmus test for the program's success. Though those figures are important, the performance of a weapons system is what the warfighter truly cares about. A tremendously capable aircraft that is delivered late and over budget will still save American lives on the battlefield. Conversely, an aircraft delivered on time and budget but without many necessary capabilities will immediately become a liability to the warfighter. Though ideal, an extremely capable aircraft delivered on time and budget has yet to be realized, while an underperforming aircraft that is delayed and over budget is an embarrassing national travesty. The obvious question is where on that paradigm the F-35 currently lies. Though many of the performance capabilities are classified, there are several examples of performance tradeoffs made due to the aircraft's joint acquisition model.

There are several roadblocks hampering a thorough analysis of the F-35's performance, but it is not premature to say that the F-35 is a tremendously capable aircraft. Several pilots have publically praised the aircraft's "dream capabilities," and another pilot said if his child had to fly in combat, he would want him in the F-35.<sup>58</sup> Although criticism of the F-35 by test pilots will admittedly be difficult to find in the public domain, these praising sentiments are not unique and

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<sup>58</sup> Ackerman, Robert. *F-35 Offers Dream Capabilities for Pilots who have Flown it*. SIGNAL Magazine, 11 Feb 2014. <http://www.afcea.org/content/?q=f-35-offers-dream-capabilities-pilots-who-have-flown-it>

they are generally echoed across the F-35 community. These general “capabilities” are generally accepted to be referring to the F-35’s fusion, advanced sensors, and other technological achievements—capabilities that are highly classified. Also, these capabilities are not yet fully developed, and only when they reach full maturation will they be worthy of the praise afforded to them. Regardless, for the purposes of this assessment, the classified capabilities of the F-35 are the next logical step in technology, and they are not a function of the joint model. The joint model will enable these capabilities to be leveraged by all branches of the US military without having to endure the arduous acquisition process for different, but similar aircraft.

One key benefit of the joint acquisition process is that improvements to the F-35’s capabilities will have more funding than aircraft utilizing traditional models. The F-35’s joint acquisition model is designed to allow many different agencies to contribute funds for upgrades to the aircraft, which therefore should allow more funding and more capability. However, that gain is offset by the fact that many different users have many different requests. The varying requests have now grown to levels that are not achievable, even with the additional funds provided by partner services and nations.<sup>59</sup> Although it is too early for final judgement, it appears that the benefit of extra funding is nullified by the additional requests of all the program’s stakeholders.

The F-35 cockpit and how it presents information to the pilot is one of its most crucial design features. Currently, F-35 pilots from the operational and developmental test communities converge at Joint Cockpit Working Groups (JCWGs) to discuss these critical aspect of the aircraft. Unfortunately, there is no common method of presenting information to pilots across all

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<sup>59</sup> Freedberg, Sydney J. *Billions in F-35 Upgrades Debated, Canada Election Fallout*, Breaking Defense, 22 Oct 2015. <http://breakingdefense.com/2015/10/billions-in-f-35-mods-debated-canada-election-fallout/>

of the legacy aircraft in the US inventory today; therefore, the pilots attending JCWGs tend to have varying requests based on their backgrounds. Each pilot is rightly convinced that his or her way is the “correct” way to present information, being as that is the only way that pilot knows how to interpret such information. Wading through the various requests and finding a design amicable to all parties is frustrating, arduous, and time consuming. It is impossible to please all parties, and as a result the F-35 will fail to present information in an ideal way to all of the pilots that will fly it. That failure can be considered another performance shortfall of the aircraft. Though this disadvantage can be trained out of pilots, it is nonetheless directly attributable to its joint acquisition model.

Perhaps the most infamous analysis of the F-35’s performance appeared in the form of a leaked flight test report written by a test pilot flying basic fighter maneuvers, or dogfighting, in an F-35 against the aircraft it is supposed to replace, the F-16. The F-35’s performance in this arena was worse than the F-16, which initially seems to be a damning indictment of the F-35.<sup>60</sup> While a full analysis of this report would double the length of this paper, what is indisputable is that the poor performance of the F-35 in a dogfight against an F-16 is a direct result of the joint acquisition model. The F-35 is required to have a very high percentage of parts common across all three variants, with the actual percentage approximately 80%.<sup>61</sup> The requirement for the F-35B to have short takeoff and landing characteristics required the aircraft to undergo massive weight savings, including a small wing.<sup>62</sup> That small wing leads to a high ratio of aircraft weight

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<sup>60</sup> Axe, David. *Test Pilot Admits The F-35 Can’t Dogfight*. War is Boring, 29 June 2015. <https://medium.com/war-is-boring/test-pilot-admits-the-f-35-can-t-dogfight-cdb9d11a875#.qti6qik1g>

<sup>61</sup> Lockheed Martin, *F-35 Lightning II, Defining the Future*, Lockheed Martin Brochure A11-34324E001, Fort Worth, Texas.

<sup>62</sup> Axe, David. *F’d. How the US and its Allies Got Stuck with the World’s Worst New Airplane*. WarIsBoring, 13 Aug 2013. <http://warisboring.com/articles/f-d-how-the-u-s-and-its-allies-got-stuck-with-the-world-s-worst-new-warplane/comment-page-1/>.

to wing area, which is known as wing loading. Basic aeronautical engineering can readily explain how a high wing loading will translate into an aircraft that cannot dogfight well. Therefore, because the Marines need a specific capability that is incredibly difficult to design into a fighter, or any aircraft, many other F-35 customers without that need are nonetheless stuck with an aircraft with high wing loading and all its associated shortfalls only because the F-35's joint acquisition model dictates it. The F-35C has a larger wing to facilitate its need to land on a carrier; however, there are limited orders for that version of the F-35. The weight savings necessary for the F-35B to fulfill the requirement of the Marines created other design tradeoffs and possible shortfalls that will not be discussed here but that affect all variants of the aircraft. Though the F-35 program office claims that aircraft was not designed for dogfighting and that its actual capabilities far outweigh any areas in which it is lacking,<sup>63</sup> many, if not all accounts name these performance tradeoffs as the biggest single downside of the joint acquisition model.<sup>64</sup>

Despite the roadblocks to a full analysis, several examples of performance shortfalls that are a direct result of the joint model are highly publicized and provide ample fodder for the aircraft's critics. These shortfalls exist because a high number of parts need to be identical between all aircraft variants. Those shortfalls are a distinct disadvantage of the joint model. Based on the lessons learned in the F-35's acquisition process, if its joint acquisition model is to be used again, the strict requirement for common parts should be reconsidered in order to prevent the unique and niche requirements of a specific partner drive significant tradeoffs for all members of the program.

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<sup>63</sup> F-35 Joint Program Office, *Joint Program Office Official Response to "War is Boring" Blog*, F-35 Program Office Press Release, 1 July 2015. <https://www.f35.com/news/detail/joint-program-office-response-to-war-is-boring-blog>

<sup>64</sup> Axe, David. *F'd. How the US and its Allies Got Stuck with the World's Worst New Airplane*. WarIsBoring, 13 Aug 2013. <http://warisboring.com/articles/f-d-how-the-u-s-and-its-allies-got-stuck-with-the-world-s-worst-new-warplane/comment-page-1/>.

## Analysis

When it reaches operational capability, the F-35 will be an airplane that offers unmatched performance in several areas and admittedly disappointing performance in others. It will field well later than its initial timeline dictated at a cost nearly double its initial budget. The joint acquisition model used to acquire the F-35 has several advantages and disadvantages that become apparent when analyzing the cost, timeline, and performance of the F-35.

The failure of the F-35 to adhere to its initial budget is not unique to its program, and such overruns are also apparent in aircraft that used the traditional acquisition model. The program's cost overruns are greater than those in previous programs; however, those overruns match a trend in aircraft acquisitions. Though the joint model did not appear to stem the growth of budget overruns, it also did not appear to accelerate the negative trend. The joint model did combine some of the costs of a new aircraft that the taxpayer otherwise would have had to pay for each individual service. Finally, the joint model did combine the vested interests of various services into one project, giving that project significant staying power in the face of calls for its cancellation—calls that have resulted in the termination or significant reduction of fighter acquisitions in the past. Though this admittedly seems to be a case of the proverbial tail wagging the dog, the need for modern technology in the hands of the warfighter will not cease. Until the cost of that technology can be kept in check, the joint acquisition model will ensure that critical projects are not unnecessarily pared down or cancelled.

The F-35 has faced embarrassing delays during its acquisition. Though some of the delays were due to shortfalls with the F-35B and therefore can be attributed to the joint acquisition model and its requirement to include all three aircraft variants, the major factor driving the

F-35's timeline is software. No other single factor comes close to affecting the timeline of the aircraft as much as its complex software, and that software would be in place regardless of whether the F-35 was acquired jointly or via a traditional model. Furthermore, although the taxpayer is stuck frustrated and impatiently waiting for the aircraft to eventually reach full capability, the joint acquisition model has ensured that the taxpayer need only suffer through one such delay. Since the delay is driving by a consideration that is not unique to one specific branch, it can be assured that the software problems plaguing the F-35 would likely affected other fighters if they were not traditionally acquired, especially if they were manufactured by someone other than Lockheed Martin. Although the delays in the program are difficult to stomach, the joint model nonetheless appears to hold an advantage to the taxpayer over the traditional model in the long run with regards to preventing such delays on other programs.

As discussed above, there are indisputable aspects of the F-35's performance that have suffered as a result of its joint acquisition model. The public has focused on one area in particular: its performance in a traditional dogfight against the airplane it is supposed to replace. The performance shortfalls of the aircraft are real, and they are a direct result of its joint acquisition model. The US military asked Lockheed Martin to design a fighter aircraft capable of doing something that fighter aircraft should not be able to do: hover in midair. Lockheed Martin delivered, but unsurprisingly, there is no such thing as a free lunch. The performance shortfalls were exacerbated by a requirement for 80% of the aircraft parts to be interchangeable among the three aircraft types. Reducing the requirement of interchangeable parts to only the necessities, such as software, engine, and other critical components will allow the designers flexibility to mitigate these performance shortfalls. Not to be forgotten, the inability of the aircraft to tailor its presentation of information perfectly to suit all stakeholders is another notable disadvantage of

the joint model. The performance shortfalls suffered across the fleet of F-35s as a result of several factors represent the single biggest disadvantage of the joint acquisition model.

At this stage in the program, it is difficult to decisively call any part of the F-35's acquisition process a success. The joint acquisition model used by the program is producing an underperforming aircraft that is over-budget and behind schedule. Regardless, it has been shown above that the joint model is nonetheless saving the American taxpayers from having to make other significant investments of both money and time that would otherwise have been necessary to produce an aircraft for use by the Navy and Marines. The costs and delays are nothing that cannot be reasonably expected based upon historical precedent. Perhaps most importantly, the joint acquisition model has already produced an F-35B that has reached initial operational capability, and the program is gaining momentum daily. Though the F-35's joint acquisition model did produce performance shortfalls that its critics will publicize at any possible moment, it has nonetheless produced an aircraft capable of defending America from the advanced threats of tomorrow. When analyzing the F-35 objectively, it is hard to see its acquisition model as anything other than at least a partial success, and one that, when tweaked, will be suitable for future fighter acquisitions.

### **Recommendation**

The joint acquisition model used by the F-35 should not be reused without any modifications; however, it holds significant advantages over traditional models. Future fighter acquisition programs should include multiple services; however, strong consideration should be given to any unique requirements stemming from one particular service that will gravely impact all others, such as the F-35B's short takeoff and landing requirement. There should be no set percentage or

requirement on the number of common parts between variants of the aircraft—if different variants are even required; rather, the manufacturer should be given the flexibility to minimize design tradeoffs that will be imposed on all variants for the requirements of one. As with this program, if one specific variant of the next fighter acquired via the joint model is underperforming, it should be possible to cut or significantly modify one variant without affecting the others. When considering the next fighter aircraft, if a single aircraft for multiple services is deemed impractical, at least the software and other critical components (to possibly include sensors and engines) should be jointly developed and fielded. The government should also negotiate a way to allow vendors to access critical software or other capabilities of competitors if required to give a new fighter the best possible foundation from which to build; petty differences and competition between companies should not put the lives of American airmen on the line by not giving them the best possible product.

The United States utilized the joint acquisition model for the F-35 because the aircraft was created in an evolving world, with new capabilities, emerging threats, and reduced budgets. The acquisition world needs to continue to evolve with the world around it by refining its processes to suit the world in which it lives, it can do that by revamping the F-35's model in the ways listed above. The joint acquisition model has plenty of advantages to leverage, and its disadvantages can likewise be mitigated. Together, the services can, and should, jointly design, build, and field a fighter that will keep Americans safe for decades to come.

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