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Distinctive Capabilities:
Addressing the Fighter Gap with the Silent Eagle

by

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Introduction

In June 2011, Eglin Air Force Base receives its first production-model F-35. While this marks a significant milestone in the Department of Defense's (DoD) biggest acquisition program, many more milestones remain. Recent government reports highlight the uncertainty of both the program cost and the tactical capabilities the F-35 will provide. In addition, even if the Air Force purchases and receives all 1,763 of its planned F-35s, the total Air Force fighter inventory will fall short of its stated goal of 2,200 fighter aircraft.[1] Along with this shortfall, the Air Force continues to struggle to find money and a timeline for the proposed "Next-Generation Bomber" which will ultimately replace the B-1 and B-52.[2] Combined, these factors cast doubt over the Air Force's ability to project power in the 2020-2050 timeframe.

The biggest cause for concern regarding F-35 acquisition is the uncertainty of the program, both in cost and war fighting capability. The latest Department of Defense (DoD) Selected Acquisition Report (SAR), dated 31 December 2010, listed the per-unit cost of the F-35 at $132.8M—an 81% increase in price from the original F-35 baseline.[3] The same report also showed the F-35 has fallen short of its combat radius requirements and can only reach targets out to a range of 580NM.[4] This paper will outline other facets of the F-35 the Lockheed Martin team has yet to prove as the program heads towards Initial Operational Capability (IOC) in 2018.

Seeking solutions to this power-projection uncertainty, the United States Senate directed the Congressional Budget Office (CBO) to seek alternatives to F-35 production. Titled *Alternatives for Modernizing US Fighter Forces,* the May 2009 CBO report predicted the severity of the impending fighter shortfall, or "fighter gap." Figure 1 below shows the CBO results, with a nominal shortfall of 500 aircraft and a worst-case shortfall

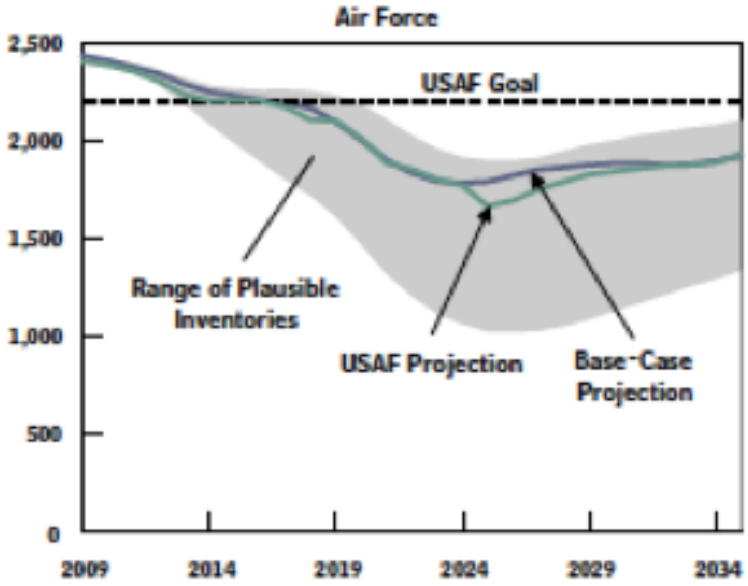

Figure 1. CBO report depiction of the fighter shortfall, with a nominal shortfall of 500 aircraft in 2025, with a worst-case shortfall of 1,200 aircraft. *(Reprinted from the 2009 CBO report "Alternatives for Modernizing the U.S. Fighter Force.")*

of 1,200 aircraft.

In addition to highlighting the shortfall, the CBO report presented seven different options for modernizing the aging fighter fleet. The options ranged widely, from accelerating the present production of F-35s to dramatically reducing the F-35 buy and supplementing the fighter force with small, unmanned aerial combat vehicles (U-CAVs).[5] Among the CBO alternatives is the option for the Air Force to supplement the fighter gap with the purchase of F-16E aircraft.[i] While the F-16E is a viable option since it provides similar performance to a non-stealthy F-35, there are additional factors to consider which should influence any new fighter acquisition.

One of the concerns with F-35 cost overruns is the impact they have had on the Air Force's attempts to procure funding for the Next-Generation Bomber (NGB), the replacement aircraft for the B-52 and B-1. According to the 2010 Quadrennial Defense Review, the Air Force is "reviewing options" for fielding a long-range strike aircraft, but

[i] The F-16E is similar to the F-16 Block 60 variant purchased by the United Arab Emirates. It has conformal fuel tanks for extended range, and an advanced electronically scanned array (AESA) radar.

the budget for the program has shrunk to zero over the last several years.[6] With the planned F-35 force construct and the projected retirement date of the F-15E Strike Eagle, the aging B-52, B-1 and B-2 will be the only Air Force aircraft able to project long-range power after 2035.[7] Current B-1, B-2 and B-52 retirement projections show the United States losing its power-projection capability beyond 600NM around the year 2040.[8]

Another benefit of a longer-range platform is its ability to execute other mission sets besides pre-planned interdiction. Arguably, the 2003 Operation Iraqi Freedom campaign was the last USAF campaign against a robust air-defense system, where a low-observable strike fighter has great utility. Since then, the A-10, F-16, and F-15E have all proven their value in low-threat air-to-ground missions such as Search, Coordination and Reconnaissance (SCAR) and Close Air Support (CAS). Specifically, the A-10 and F-15E have succeeded due to their loiter ability, providing ground support for over two hours without refueling. Recently, Operation Odyssey Dawn (OOD) in Libya again proved the value of these aircraft. Although B-2s accomplished the initial Integrated Air Defense System (IADS) takedown, the F-15E demonstrated its ability to fly long distances, loiter in the area to select targets, and successfully engage those targets.[9] Notably absent in OOD was the F-22, proving not all conflicts require a low-observable fighter asset.[10]

Looking at all these factors together, the Air Force faces an uncertain future of power projection. The F-35 will undoubtedly herald an unprecedented era of attack aviation, but it is certainly costly and has range and payload limitations to its utility. The 2009 CBO report attempted to address these concerns, but none of its seven alternative options solved the capability dilemma. The options, which this paper will detail further, either left the Air Force with a significantly reduced fighter force (in favor of bombers),

or precluded the option of any medium-range strike in the 600NM to 1000NM region.

Enter the F-15 Silent Eagle (F-15SE), an option which the CBO report did not address, yet one which presents a solution for the USAF to bridge the fighter gap in the 2020-2050 timeframe. Although not as stealthy as the F-22 or F-35, the F-15SE is the most versatile fighter platform existing in the world today. It can augment the F-22 and F-35 in air-to-air battle as a semi-stealthy, heavily armed high-performance fighter. Alternatively, it easily reconfigures to accommodate all the air-to-ground ordnance options of the F-15E Strike Eagle. Once configured this way, the F-15SE offers distinctive capabilities when compared to the F-35. Specifically, the F-15SE carries more ordnance types and has a significantly higher combat radius than the F-35. In addition, a single F-15SE can carry a heavier and more versatile weapons load than an F-35, making it ideal for a range of targets or mission sets in a short period of time. Not only would acquiring the F-15SE help fill the fighter gap with a distinctive platform, but it would also help the USAF keep a medium-range fighter-bomber in the inventory to help fill the deep interdiction role while the USAF acquires, builds and fields the next-generation bomber.

Background

Plan for the 2020-2050 USAF Fighter Force Structure and the Fighter Gap

From 2008 to 2011 the Department of Defense (DoD) and USAF have had changing predictions of what the overall force structure will look like from 2020-2050. In 2008 the Air Force predicted the fighter shortfall to peak at roughly 800 aircraft.[11] The CBO's *Alternatives for Modernizing U.S. Fighter Forces* in 2009 placed the gap nominally at 500 aircraft by 2025, with a maximum potential shortfall of 1,200 aircraft.[12] Most recently, the USAF released reports in 2010 showing a shortfall of only 200 aircraft.[13] These successive reports suggest the fighter gap may not be as serious as originally thought—but they also tell only a partial story about the future of fighter production, modification, and sustainment.

Importantly, according to the most recent GAO report on the Air Force's shortfall predictions, the Air Force is making significant presumptions in predicting a fighter shortfall of only 200 aircraft. First, the Air Force reports assume F-35 peak production at roughly 80 aircraft per year to replace aging F-16s and A-10s, yet even as the Air Force published the reports, the Secretary of Defense mandated a slowdown of initial F-35 procurement due to setbacks in development.[14] Second, the Air Force's plans to maintain fighter force structure hinge on the Service Life Extension Program (SLEP) for the F-16, meant to extend the F-16 airframe from 6,000 to 8,000 hours of serviceable life. The GAO report noted SLEP testing of the F-16 airframe will not be complete until the end of 2011, and doubt remains regarding its outcome.[15] By making these assumptions when calculating the total fighter shortfall, the Air Force accepts moderate risk. If F-35 production falls further behind schedule, or the F-16 airframe cannot safely be flown out

to 8,000 hours, the fighter gap could quickly climb back up to 500-1,000 aircraft.

In addition to exposing uncertainty in the Air Force's fighter shortfall predictions, the GAO noted in its research that the Air Force seemed closed to the idea of non-stealthy fighters as part of the force structure. Speaking to the USAF reports, the GAO noted: "The reports presented limited new analyses and primarily summarized the Air Force's long-standing plan to transition to an all-stealth 5th generation fighter force and the desire therefore to avoid large investments in legacy, non-stealth fighters that could divert funds from this plan."[16] The Air Force has made stealth a clear number-one priority for the tactical fighter force—yet doubt remains regarding the true capabilities such a force will provide, and at what cost.

The F-35: Cost Overruns and Capability Limitations

The two biggest concerns over the F-35 program revolve around the cost—both in procuring and operating the airframe—and the capabilities of the platform. The 2010 GAO report *Joint Strike Fighter: Additional Costs and Delays Risk Not Meeting Warfighter Requirements on Time* states bluntly: "JSF cost increases, schedule delays, and continuing technical problems…increase the risk that the program will not be able to deliver the aircraft quantities and capabilities in the time required by the warfighter."[17]

As the F-35 program nears initial operational capability (IOC), several organizations have attempted to determine the increases in per-unit cost. The 2010 GAO report laid out the approved budget for the program from 2001 to 2011, showing a per-unit cost increase from $69m to $112m, a 62% increase.[18] Simultaneously, the DoD's Defense Acquisition Management Information Retrieval (DAMIR) branch conducted a Selected Acquisition Report (SAR) showing the per-unit cost at $132.8m.[19] Notably, the

same SAR report from 2009 showed a per-unit cost of $113.6m. This means the per-unit cost estimate for the F-35 increased over $19m in just one year. Importantly, the SAR $132.8m per-unit estimate is based on the DoD purchasing all 2,457 F-35s it plans to. Should the DoD purchase fewer F-35s, the per-unit cost will increase further due to the overhead development costs.

Even though the first production F-35 will arrive at Eglin Air Force Base in June of 2011, a very high likelihood for increased production costs exists. The 2010 GAO report highlights several significant concerns regarding F-35 fielding issues. First, the F-35 is a more computer-driven aircraft than any previous fighter. In fact, the F-35 will eventually have over 11.6 million lines of computer code, compared to 2.2 million lines of code for the F-22.[20] While software engineers have completed over three-fourths of the code, only 40% of it has been integrated and tested on the airframe.[21] The GAO report says of the integrating and testing: "This is typically the most challenging phase of software development. The program…keeps moving some capabilities to future blocks in order to keep on schedule. This adds pressure and costs to future efforts and increases the probability of defects being realized later in the program."[22] In addition to this problem, many of the capabilities required of the F-35 have only been proven in simulations. In fact, of the 2,879 aircraft capabilities required in the contract, only 62 had been proven in the field as of the 2010 GAO report—less than 3% of the requirement.[23] The other 97% of field testing, combined with the lagging software development, creates well-founded concern about the per-unit cost of the airframe continuing to increase—perhaps substantially—past the $132.8m mark.

Even more elusive than the up-front cost for each F-35 is the eventual cost the Air

Force will pay to sustain and operate the platform. Conceived as a tactical fighter to replace the F-16, A-10 and F-18, the JSF was supposed to have Operating and Sustainment (O&S) costs less than or equivalent to an F-16. Since much of the airframe testing lies in the future, it is difficult to assess what measure of cost-effective maintenance the F-35 will achieve. Already, however, initial reports point towards higher-than-expected O&S costs. The DAMIR SAR report noted that a DoD Cost Analysis and Program Evaluation (CAPE) review is pending, but put an initial estimate of $16,425 per hour on the F-35 O&S costs.[24] This compares to $13,466 per hour for the F-16. Meanwhile, Christine Fox, the head of CAPE, reported that the JSF's sustainment costs "…are not quite as high as that of its larger fifth-generation sibling, the F-22 Raptor, but match those of the older and considerably larger F-15C Eagle."[25] With the 1,763 F-35s the Air Force plans to procure, the operating costs could potentially be enormous. One Pentagon report estimates the total O&S costs of the F-35 at over $1 trillion.[26]

The Air Force counters the F-35's significant price tag with the argument of increased capability. Senior leadership points to the airframe's ability to operate in anti-access environments and achieve unprecedented tactical effects.[27] Granted, stealth capability is proven technology and has yielded prior success in combat. On the other hand, the stealth technology in the F-35 is questionable, and the insistence on a 5th Generation fighter force will leave the Air Force lacking in other capabilities.

In 2009, one of the senior members of the American Institute of Aeronautics and Astronautics, Dr. Carlo Kopp, wrote an interesting thesis for the Australian Airpower Journal titled *Assessing Joint Strike Fighter Defence Penetration Capabilities*. In it, he

argues the F-35 is not a true stealth platform in the same vein as the B-2, F-117 and F-22. His argument begins with the physical shape of the F-35, which has changed from the initial prototype to accommodate a larger weapons bay and sensor requirements. He accomplishes a mathematical analysis of shape and radar reflection and concludes, based on shape alone, that the F-35 is only stealthy from a small aperture of aspects.[28](Kopp, 3) Figure 2 shows the initial X-35 prototype and the current F-35 shape differences Dr. Kopp used to draw his conclusions.

Figure 2. Images showing the design changes in the F-35 that Dr. Kopp argues lead to less-than-optimal stealth capability. *(Adapted from "Assessing Joint Strike Fighter Defence Penetration Capabilities.")*

Dr. Kopp couples his shaping argument with an assessment of the very anti-access environment the F-35 is supposed to penetrate. His analysis includes the specifications of Russian and Chinese-made defense systems, and concludes based on the use of multiple emitters and frequency types that these defense systems will be able to successfully target the F-35.[29] Figure 3 shows how this "system of systems" will engage the F-35.

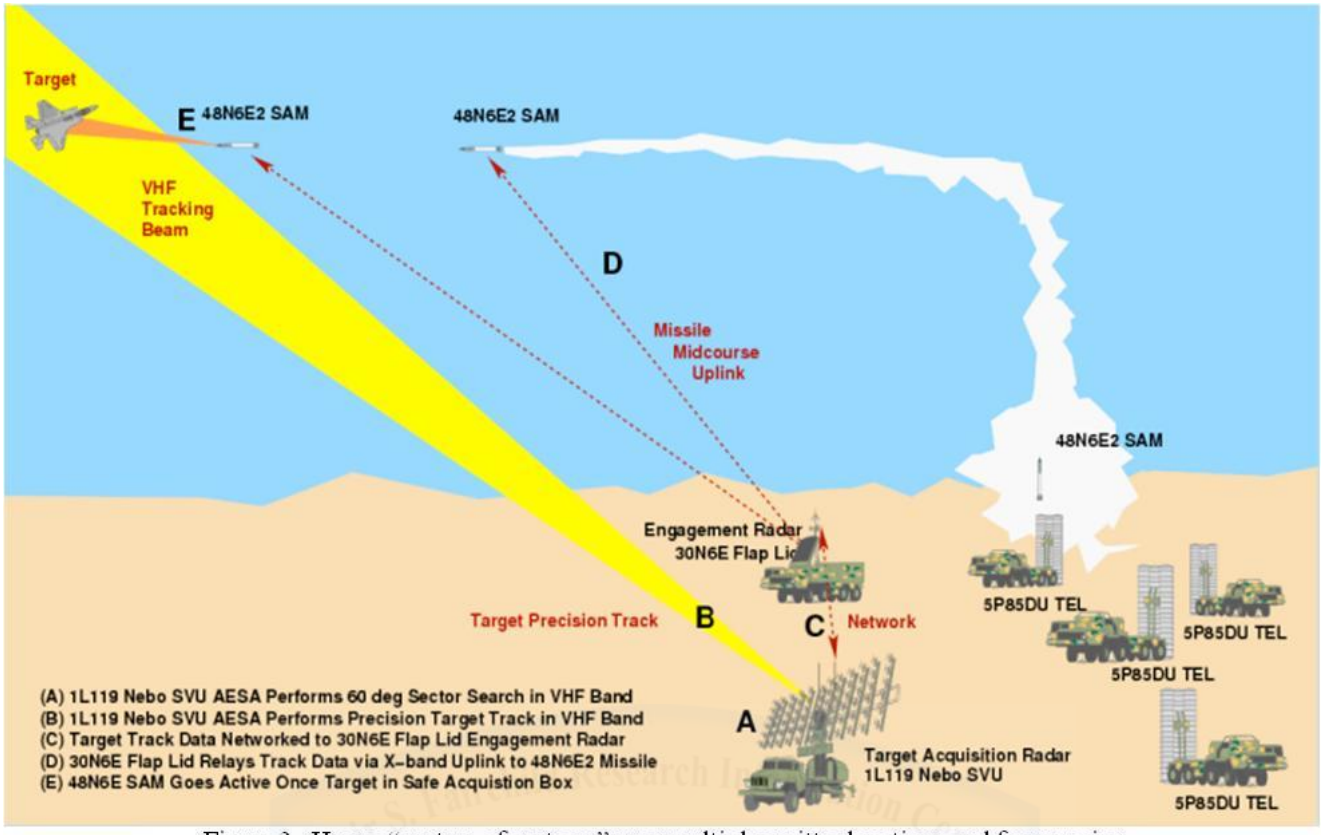

Figure 3. How a "system of systems" uses multiple emitter locations and frequencies to engage a Low-Observable target. *(Reprinted from "Assessing Joint Strike Fighter Defence Penetration Capabilities.")*

Certainly, Dr. Kopp's conclusions are debatable, and the actual stealth characteristics of the F-35 are classified. Not in doubt, however, are other F-35 capability limitations based solely on performance specifications. First, the JSF will be limited to a combat radius of roughly 590NM according to the DAMIR SAR.[30] While this radius is greater than the F-16, it is significantly less than the 900NM radius that today's F-15E Strike Eagle can achieve. With the F-15E set to retire in 2035 and no next-generation bomber (NGB) platform funded, this will limit America's global strike capability. In addition, the F-35 significantly lags its stealth cousin, the F-22, in top speed. This speed differential means it will have difficulty integrating with the F-22 in air-to-air engagements. Lastly, the F-35 significantly sacrifices weapons payload for stealth. Internally carrying ordnance to maintain a stealthy profile, the F-35 will only

carry four missiles (as compared to eight for the F-22), or two missiles and two 2,000lb weapons. In its air-to-ground, non-stealthy configuration, the F-35 can carry more ordnance than an F-16, but still less than the F-15E—and external weapons are predicted to have a significant effect on the F-35s combat radius.[31] Although external ordnance carriage has yet to be tested on the F-35, a full comparison of the F-35's carrying capacity, combat radius and speed relative to alternative platforms is provided in the Evaluation section of this paper.

The Next-Generation Bomber: All Quiet on the Acquisition Front

One of the unfortunate side effects of F-35 cost overruns is the delay or sacrifice of other USAF programs in order get the F-35 on timeline. One of these programs is the Next-Generation Bomber (NGB), the planned replacement for the B-1 and B-52 airframes. Since the turn of the century, the target year for fielding of an updated bomber has been 2018. This date corresponds with the retirement of the Air-Launched Cruise Missile (ALCM), one of the B-52's primary standoff weapons. In the last few years, however, development funding for the NGB has waned, and finally in 2009 Secretary of Defense Gates canceled the funding altogether.[32] Figure 4 shows the decrease in funding for NGB procurement from 2004 to 2010.

FY20045-FY2009, in millions of dollars, rounded to nearest tenth

FY2004	FY2005	FY2006	FY2007	FY2008	FY2009
44.2	28.9	24.1	37.5	7.0	0

Source: Prepared by CRS based on justification books for the Air Force research and development accounts for FY2010 and prior years.

Notes: Funding in FY2004 and FY2005 was added by Congress.

Figure 4. Funding for development & procurement of the Next-Generation Bomber from 2004 to 2009. *(Reprinted from the 2009 Congressional Research Report "Air Force Next-Generation Bomber: Background and Issues for Congress.")*

As a response to Secretary Gates' canceling of the NGB funding, CSAF Schwartz said he wanted the Pentagon "…to acknowledge that there is a requirement for the armed forces to own a long-range strike capability."[33] This acknowledgement, however, came third on the list of CSAF Schwartz's stated priorities. In the same speech, he listed his first priority as modernizing existing fighters, followed by accelerating F-35 production.[34]

The Air Force still has 20 years or more to develop and acquire the NGB before the B-52, B-1 and B-2 fleets begin to retire, so the current lack of NGB funding is not catastrophic. Without forethought, however, in 2040 the Air Force will run out of bombers and the ability to project air-to-ground ordnance further than the F-35's range of 590NM.

Alternative Solutions for the Fighter Force

The 2009 CBO Study *Alternatives for Modernizing the U.S. Fighter Force*

The F-35 cost overruns and capability concerns have caused American political leadership to look for alternatives to an all-5th generation fighter force. Even though CSAF Schwartz has flatly stated there will be no "Generation 4.5"[i] fighter purchase, Congress has had the CBO assess exact solution, among others.[35] The CBO report laid out seven alternative options to the current modernization plan, then analyzed them from both a cost perspective and a capabilities perspective. Of the seven options, four accepted a fighter shortfall, either outright or by replacing fighter force structure with notional unmanned combat aerial vehicles (UCAVs) or medium-range bombers.[36] For the purposes of this paper, those four options diverge drastically from the USAF's stated force posture and therefore will not be detailed. The remaining three alternatives, however, all provide a solution to the fighter shortfall. Under Alternative 1, the DoD would accelerate the production of F-35s and eventually increase the total buy, bringing the total USAF fighter force to the desired 2,200 aircraft. Under Alternative 2, the USAF would decrease by roughly 270 the number of F-35s, and instead purchase 435 F-16E aircraft as a cheaper light-attack alternative. Under Alternative 3, the USAF would scrap the F-35 altogether and replace it with 1,925 F-16Es.[37] From strictly a cost perspective, the CBO Alternatives provide fascinating results, listed in Figure 5.

[i] "Generation 4.5" is the term used to denote fighter aircraft built from proven airframes, but with updated avionics—notably Advanced Electronically Scanned Array (AESA) radar, modern electronic warfare suite, and/or integrated data link. Any new versions of the A-10, F-16, F/A-18 and F-15 fall into the Generation 4.5 category

CBO Alternative and Description	Total Investment Cost compared to current DoD Plan	Remarks
Alternative 1: Satisfy Inventory Requirements by Accelerating/Increasing Purchases of JSFs	**Plus $5 Billion**	Based on an average per-unit cost (APUC) of $67m. Since the study was conducted, APUC has risen to $132m
Alternative 2: Satisfy Inventory Requirements by Purchasing JSFs and Improved Legacy Aircraft	**Plus $8 Billion**	Includes $2 Billion for F-16E R&D
Alternative 3: Cancel the JSF Program and Satisfy Inventory Requirements by Purchasing Improved Legacy Aircraft	**Minus $31 Billion**	Difficult to execute with foreign aid already invested in F-35 program

Figure 5. Cost comparison of three alternatives to the current DoD fighter acquisition plan. *(Adapted from the 2009 CBO report "Alternatives for Modernizing the U.S. Fighter Force.")*

Not surprisingly, the CBO study found the F-35 program as costly compared to Generation 4.5 fighters. Under Alternative 3, the DoD would save $31 billion, a figure incorporating the $5 billion the U.S. would have to pay back to foreign investors in the program. Perhaps more surprisingly, however, the CBO found that purchasing *more* F-35s to fill the fighter gap would be slightly less expensive, at least in investment costs, than supplementing the F-35 with the F-16E. The CBO study drew these conclusions mostly from the extra cost incurred from a separate logistics trail following a weapons system.[38] Importantly, though, the CBO's findings were based on a per-unit procurement cost of $67 million for the F-35.[39] Since the study, the predicted per-unit cost has nearly doubled to $132.8 million—meaning with the latest cost estimates for the F-35, Alternative 2 would actually be less expensive.[40] In addition, the CBO study did not consider O&S costs—only procurement costs. Although the CAPE data on F-35 O&S is

not yet available, it is reasonable to assume the F-16Es purchased in Alternative 2 would cost less to operate per flight hour than additional F-35s during their lifetime.

In his 2010 Air War College paper *The USAF Fighter Force Structure in the 2020-2040 Timeframe*, Col Todd Bakita backs the argument for CBO Alternative 2, the purchase of F-16Es to supplement the F-35 force. Col Bakita bases his argument on the relatively known acquisition costs of the F-16E compared to the timeline and financial problems plaguing the F-35 program. The F-16E is "singularly distinctive," he claims, because it is "available, affordable, and adaptable to the vast mission requirements of hybrid warfare."[41] The rapidly rising per-unit cost of the F-35 has borne out Col Bakita's conclusions from an acquisitions cost perspective. From a capabilities perspective, however, the Air Force has additional factors to consider.

Regarding capabilities of America's future fighter force, the CBO study focused on three main areas: stealth, AESA radar, and combat radius versus payload. Under current DoD modernization plans and the aforementioned CBO alternatives, the future fighter force appears fairly healthy from a stealth and AESA radar perspective.[42] See Figure 6.

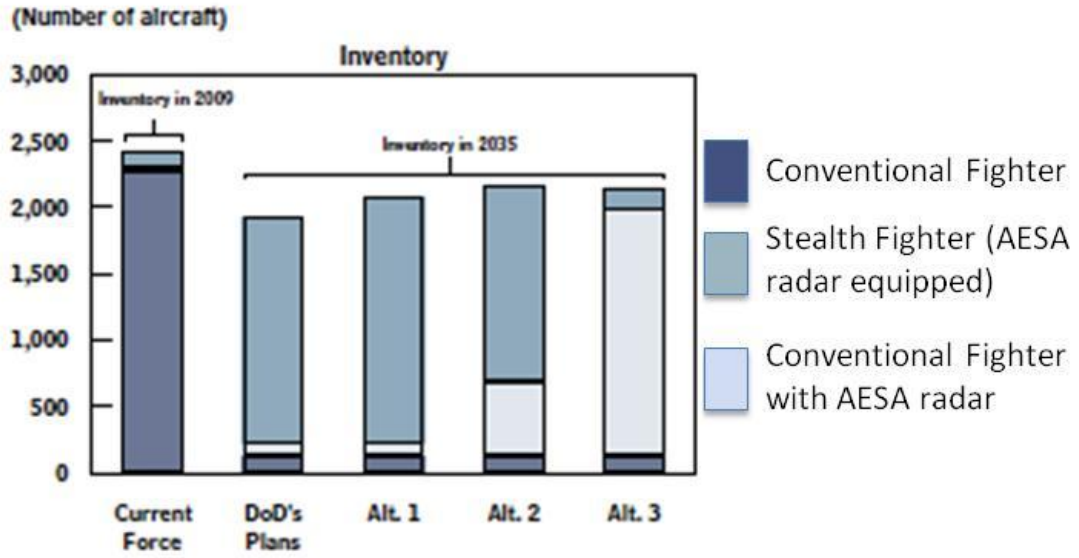

Figure 6. Force size & capability comparison showing the projected number of fighters with AESA radar, under current DOD plans and the CBO study's three alternative plans. *(Adapted from the 2009 CBO report "Alternatives for Modernizing the U.S. Fighter Force.")*

Contrasting Figure 6, Figure 7 shows the F-35 significantly increasing USAF combat capability from a weapons-carriage standpoint. The overall carriage capacity increases due to the F-35's ability to carry more 2,000lb weapons than the F-16. Beyond 590NM, however, Figure 7 shows a dramatic capability drop-off. Importantly, Figure 7 assumes the Air Force will retain the F-15E Strike Eagle through the year 2035—in fact,

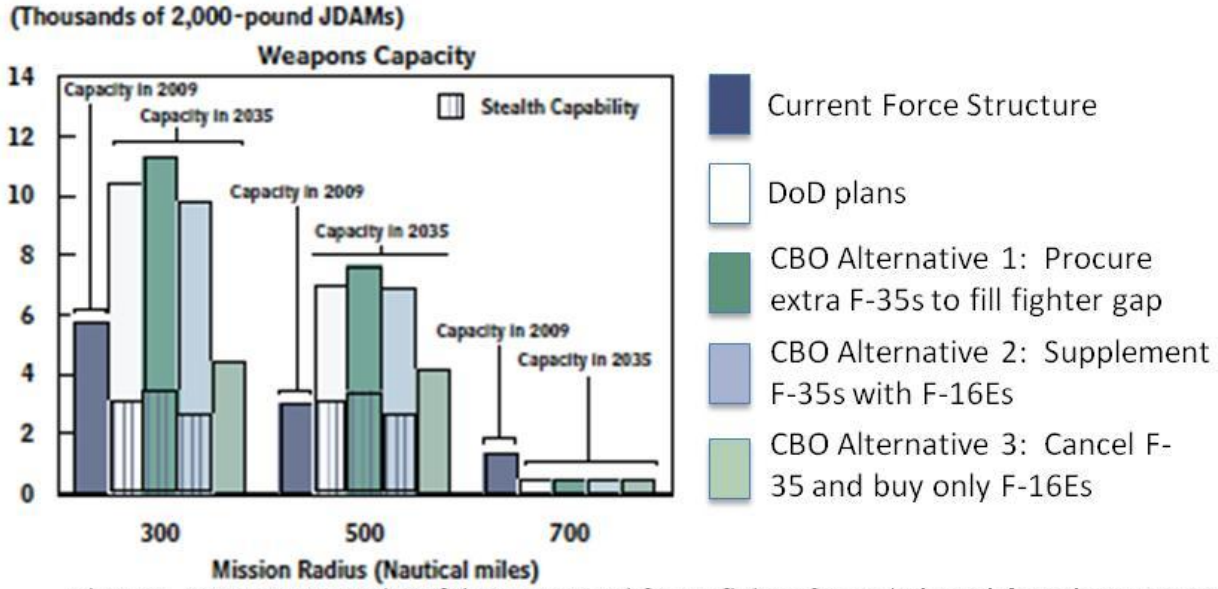

Figure 7. Weapons Capacity of the current and future fighter force. *(Adapted from the 2009 CBO report "Alternatives for Modernizing the U.S. Fighter Force.")*

under all the CBO alternatives in Figure 7, the only fighter able to deliver ordnance beyond 590NM in 2035 will be F-15E, set to retire the same year.[43]

Tactical radius is only one consideration for capability when discussing ordnance delivery. Another consideration the CBO study notes is total weapons delivery capacity. Figure 8 shows the overall weapons carriage capacity for current and future fighters.

Weapons Capacity and Mission Range of the Air Force's Current and Future Fighter Aircraft

(Number of weapons)

	Current Fleet					Future Fleet	
	A-10 Thunderbolt II	F-15 Eagle	F-15E Strike Eagle	F-16 Fighting Falcon	F-22 Raptor	F-35A JSF	Medium-Range Bomber
Maximum Air-to-Ground Weapons Capacity							
Small munitions	24	0	28	16	8/8 [a]	8/24 [a]	40
Large munitions	6	0	5	4	0	2/6 [a]	10
Air-to-Ground Weapons Capacity for Large Munitions, Out to a Specified Mission Radius							
400 n. mi.	4	0	5	2	0	2/6 [a]	10
500 n. mi.	4	0	5	0	0	2/4 [a]	10
600 n. mi.	2	0	5	0	0	2/2 [a]	10
700 n. mi.	2	0	2	0	0	0	10
Air-to-Air Weapons Capacity	0	8	8	6	8/12 [a]	4/10 [a]	0

a. Stealth capacity/total capacity. (Stealth capacity indicates that weapons are carried exclusively in internal bays. Total capacity indicates that weapons are carried both in internal bays and on external racks.)

Figure 8. Weapons Carriage capability of current and future USAF fighters. *(Adapted from the 2009 CBO report "Alternatives for Modernizing the U.S. Fighter Force.")*

Figure 8 clearly shows the F-15E carrying both more Air-to-Air and Air-to-Ground ordnance than the F-35. One of the most important aspects of Figure 8 is the limit on the F-35's weapons capacity in stealth configuration. In order to carry more than two weapons, the F-35 must carry them externally—sacrificing its stealth. Depending on mission profile, the F-15E can carry more than double the ordnance of an F-35. Lastly,

figure 8 shows the carriage limitations of the F-16. Replacing the F-35 with the F-16E means an overall reduction in weapons carriage capacity.

Another Alternative to Supplement the F-35: The F-15SE "Silent Eagle"

While the CBO was preparing its 2009 report, the Boeing Corporation was busy preparing another Generation 4.5 fighter, the F-15SE, as a Foreign Military Sales (FMS) platform to nations unable to afford the F-35. Like the F-16E, the Silent Eagle is equipped with an AESA radar and updated avionics, allowing it to integrate into 5th-generation force packages. Unlike the F-16E, Boeing has engineered the F-15SE to carry missiles internally, like the F-22 or F-35. In addition, Boeing has modified the F-15SE's shape and materials from the F-15E platform to make it more difficult to detect.[44] Although not truly a stealth platform, the F-15SE's low-observable characteristics will delay an adversary's ability to target it, making it more survivable. Most importantly from a capabilities perspective, the F-15SE can be easily reconfigured to carry the same compliment of ordnance as the F-15E. The full range of weapons options for the F-15SE is shown in Figure 9.

Figure 9. Weapons Carriage capability of F-15SE "Silent Eagle".
(Reprinted from a 2010 Boeing Presentation, "Silent Eagle Overview.")

The option to change configurations allows the F-15SE to compliment the F-22 as a semi-stealthy Air-to-Air fighter, then fly the next day as a medium-range strike platform with a higher range and heavier weapons load than the F-35.

Although not developed in time for the CBO report, the F-15SE provides another option for filling the fighter shortfall in the mid-21st century. This paper will evaluate the F-15SE from a cost and capabilities standpoint against the F-22, F-35, and the CBO's Generation 4.5 fighter choice, the F-16E.

Evaluation of Fighter Platforms

"Alternative 15SE[i]": A Better Generation 4.5 Solution

Under the CBO study's Alternative 2, the Air Force would buy 270 fewer F-35s and replace them with 435 F-16Es.[45] This solution would fill the fighter shortfall by providing more fighters to the force. The downside to this alternative, however, is the overall increased cost to the DoD to support more fighter airframes. In addition, the F-16E provides few, if any, capabilities the F-35 does not.

"Alternative 15SE" picks up where the CBO study left off by including the F-15SE in the options of Generation 4.5 fighters available to supplement the F-35 in the USAF fighter force structure. This paper will specifically assume that under "Alternative 15SE," the Air Force still buys 270 fewer F-35s, but replaces them with 270 F-15SE Silent Eagles instead of 435 F-16Es.

The Cost Comparison of Fighters Including the F-15SE

As the CBO report highlighted, acquisition cost is one of the biggest factors in determining alternatives to the F-35. Additionally, the Air Force needs to consider the operating costs over the life of the airframe.

Assessing both the per-unit cost and the per-hour flight cost of each airframe is complex and entails using many assumptions about the factors included in each price estimate. Even for older fighters, discrepancies exist from different government organizations regarding price points both for acquiring and operating platforms. For example, a quick Internet search for the price of an F-22 yields results ranging from just over $100m to $350m per aircraft. Therefore, drawing inflexible conclusions using cost

[i] "Alternative 15SE" is a term coined by the author to represent a buy of F-15SE "Silent Eagles" to supplement the F-35 force.

data alone is risky because it assumes all the assumptions about each platform's cost are equivalent and accurate. Still, without an educated guess at the costs associated with each platform, comparing their respective economic value is difficult. Figure 10 shows relative acquisition cost and O&S costs for each airframe, with remarks on the source of the information and assumptions given in the figure.

Airframe	Acquisition Cost for One Aircraft	Remarks / Assumptions	Operating & Sustainment (O&S) cost, per flight hour	Remarks / Assumptions
F-22	**$154m[1]**	Average per-unit cost based on the USAF FY2009 budget estimates. Any future F-22 procurements are estimated at $135 million per copy	**$19,000[6]**	Based on USAF 2008 F-22 and F-15 cost comparison breakdown
F-35	**Low estimate: $112m[2]** **High estimate: $132.8m[3]**	Low estimate from a 2010 GAO Report. High estimate from the 2010 DAMIR SAR figures.	**$16,425[3]**	Best estimate of DAMIR SAR report. CAPE figures not yet available.
F-16E	**$50m[4]**	Based on Lockheed-Martin Estimates	**$13,466[3]**	From DAMIR SAR report.
F-15SE	**$90-100m[5]**	Based on Boeing Estimates	**$17,000[6]**	Based on USAF 2008 F-22 and F-15 cost comparison breakdown

Figure 10. Cost Comparison of the F-22, F-35, F-16E and F-15SE.

Adapted from multiple sources:

1. *United States Air Force, "FY2009 Budget Estmates, 1-13.*
2. *Government Accountability Office, "Joint Strike Fighter—Additional Costs and Delays Risk Not Meeting Warfighter Requirements on Time," 13.*
3. *Defense Acquisition Management Information Retrieval, "Selected Acquisition Report," 38.*
4. *Congressional Budget Office, "Aternatives for Modernizing U.S. Fighter Forces," 70.*
5. *Butler, "Stealthy F-15 Could Enliven St. Louis Facility," 3.*
6. *United States Air Force, "Response to Washington Post Article by Jeff Smith," 3.*

Again, the costs in Figure 10 are debatable based on the included variables in the costs. The O&S costs listed in Figure 10 are the Air Force's *Variable Cost Per Flying Hour (Variable CPFH)*, a calculation including fuel, line maintenance, and some contract maintenance.[46] The Variable CPFH does not include all costs, however. The Air Force also calculates an *Operational CPFH*, which includes contractor support costs and other government costs. Variable CPFH and Operational CPFH vary widely—for example, the Operational CFPH of the F-22 is *$49,000* per flight hour as opposed to the $19,000 Variable CPFH.[47] The reasons for the vast differences are too various to outline here, but for the purposes of this paper, the Variable CPFH O&S costs for each of the listed platforms have roughly the same variables associated with them and thus can be reasonably compared.

Assuming the costs associated with each platform in Figure 10 are accurate, Figure 11 compares the costs to the DoD associated with purchasing and owning the

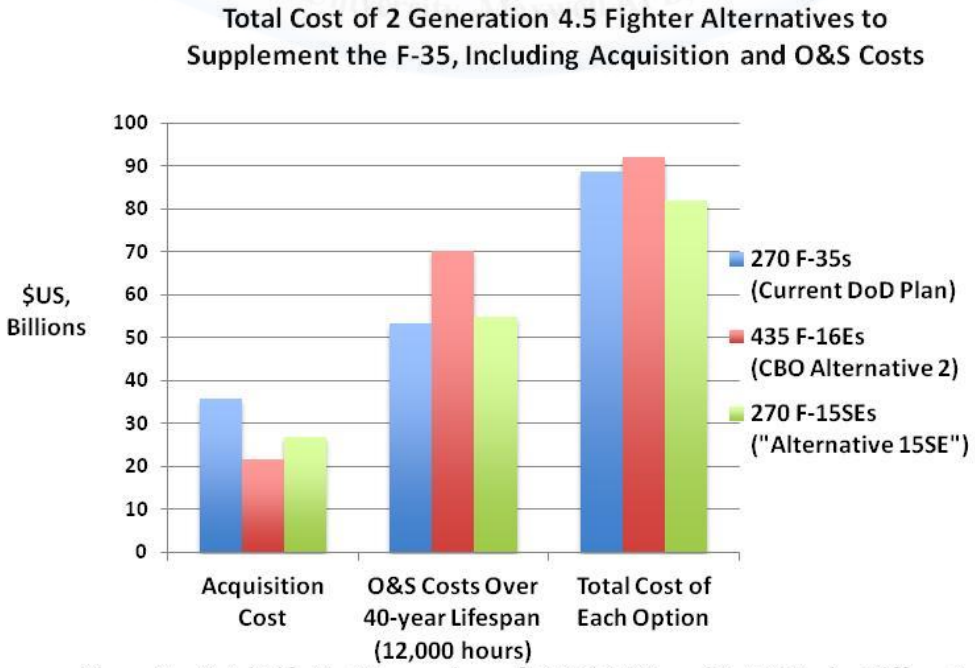

Figure 11. Total Life Cost Comparison of F-35, F-16E, and F-15E Under Different Fighter Acquisition Options.
(All Acquisition and O&S Costs compiled from Figure 10.)

planned 270 F-35s, the CBO-alternative 435 F-16Es, and 270 F-15SEs under Alternative 15SE.

By combining the CBO report data on the acquisition of the F-16E with the additional fighters in the inventory and corresponding costs, Figure 11 shows the total cost of CBO's Alternative 2 as about $3 billion higher than the DoD's plans. On the other hand, exchanging 270 F-35s for 270 F-15SEs, "Alternative 15SE" would save the government roughly $8 billion during the life of the airframes.

The logical counter to the reduced total cost of "Alternative 15SE" is one of numbers and capability. Purchasing equal number of aircraft will not supplement the fighter gap from a numbers perspective—the Air Force would still be approximately 200 fighters short of its stated goal of 2,200 aircraft in the year 3035. The F-15SE's inherent distinctive capabilities, however, bear scrutiny to assess the tactical advantage it adds to the future fighter force structure.

The Capability Comparison of Fighters Including the F-15SE

The most important reason to address "Alternative 15SE" as a supplement to the F-35 is the array of capabilities the F-15SE provides to Combatant Commanders. Boeing advertises the Silent Eagle as "Tactically Relevant Stealth."[48] Instead of the F-35 approach, where many performance characteristics have been sacrificed to attain a stealth profile, Boeing used the inverse approach of making a tried platform better with a reduction in radar cross-section. Thus, the F-35 is a *revolution* in stealth technology, while the F-15SE is but an *evolution.* As the F-15 platform evolves, however, it does so without any performance sacrifice at all—in fact, with AESA radar, digital electronic warfare suite (DEWS), and modern avionics, the platform keeps getting better. As a

larger, more powerful platform than the F-16E, the Silent Eagle provides distinctive combat capabilities the F-16E cannot. Figure 12 compares key performance parameters of the F-22, F-35, F-16E, and F-15SE.

Capabilities	F-22[1]	F-35[2]	F-16E[3]	F-15SE[4]
Stealth	Yes	Yes	No	Limited
Top Speed	Mach 2+	Mach 1.6	Mach 1.6	Mach 2+
A/A Internal Load (stealthy)	8 missiles, 480 rounds gun	4 missiles, 180 rounds gun`	N/A	4 missiles, 500 rounds gun
A/A Full Load (Non-stealthy)	12 missiles, 480 rounds gun	10 missiles, 180 rounds gun	6 missiles, 500 rounds gun	12 missiles, 500 rounds gun
Max A/G Internal Load, lbs. (stealthy)	2,000 lbs	4,000 lbs	N/A	2,000 lbs
Max A/G load, lbs. (non-stealthy)	2,000 lbs	18,000 lbs (not yet tested)	8,000 lbs	Up to 29,000 lbs— 10,000 lbs with external fuel
Max number of small munitions (GBU-39)	8	24 (not yet tested)	16	28
Max number of medium munitions (500#)	0	6 (not yet tested)	4	15— 13 with external fuel
Max number of large munitions (1,000-2,000#)	2	6 (not yet tested)	2	7— 5 with external fuel
Special munitions: AGM-158 JAASM or EGBU-28 5000# bunker-buster	0	2 (not yet tested)	0	3
Combat Radius, Medium Weapons Load	450NM[1a]	584NM[2a]	450NM	900NM
Combat Radius, Heavy Weapons Load	N/A	400NM[2b] (not yet tested)	400NM	700NM

Figure 12. Air-to-Air and Air-to-Ground Capability Comparison of F-22, F-35, F-16E, and F-15E

Adapted from multiple sources:

1. Unless otherwise noted, from USAF F-22 Fact Sheet, 1.

1a. Lockheed Martin, "F-22 Raptor Team Website: Flight Test Data," 1.

2. Unless otherwise noted, from Lockheed "What F-35 Provides to the Warfighter," 9.

2a. Defense Acquisition Management Information Retrieval, "Selected Acquisition Report," 10.

2b. Congressional Budget Office, "Aternatives for Modernizing U.S. Fighter Forces," 70.

3. Congressional Budget Office, "Alternatives for Modernizing U.S. Fighter Forces," 47.

4. Boeing Corporation, "F-15E Silent Eagle Overview," 9.

The F-15SE in Air-to-Air Combat

The first four performance comparisons in Figure 12: stealth, top speed, Air-to-Air internal load, and total Air-to-Air load, show how the four fighters compare in an Air-to-Air arena. Certainly, stealth will be a factor in future air combat, and the F-22 and the F-35 clearly have an advantage here as both platforms are built specifically to be stealthy. The F-16E, CBO's proposed alternative to the F-35, is truly a non-stealthy platform. The Silent Eagle, however, has a limited stealth ability—although potential adversaries will be able to detect it, their detection will be late compared to the F-16E. Later detection still gives the F-15SE a tactical advantage when compared to the F-16E.

Another factor in comparing capabilities is the speed of the aircraft. In modern air-to-air combat, the speed of the aircraft directly affects missile employment ranges and the ability to counter adversary tactics. In general, the higher and faster a fighter can get, the more of a tactical advantage it has. Compared to both the F-35 and F-16E, the Silent Eagle is superior from this standpoint because its ability to dash above Mach 2 helps it operate alongside the F-22, where the F-22 literally leaves the single-engine airframes behind. In fact, the Silent Eagle would continue mixed-fighter-force tactics the Air Force employs today with F-15C and F-22 aircraft. Using these tactics, the F-15s "fly in front with the F-22s, and have the persistence [because of larger fuel loads] to stay there while the [stealthy fighters] are conducting their LO attack."[49]

Another consideration for Air-to-Air capability is the amount of ordnance a fighter can carry. As Figure 12 shows, the F-15SE rivals the F-35 in internal ordnance capacity, carrying the same number of missiles internally and over 300 more bullets. Perhaps even more importantly, the Silent Eagle can be outfitted with a full complement

of 12 missiles if required to face a large number of enemy fighters—double the number the F-16E can carry.

It is difficult at this stage to assess what value the F-35's stealth will add to Air-to-Air conflict compared to the speed and ordnance of both the F-22 and F-15SE. Certainly, though, the F-15SE is a superior alternative to the F-16E in the Air-to-Air arena, as it can get to the fight faster, loiter longer, and carry more ordnance.

The F-15SE in Air-to-Ground Combat

Although the F-15SE is a formidable Air-to-Air platform, its Air-to-Ground capabilities truly distinguish it as the best choice to supplement the F-35. Figure 12 outlines some of the performance parameters defining a strike platform's capability, including number of munitions, variance in munitions type, and combat radius based on weapons load. Notably, Figure 12 shows the significant increase in Air-to-Ground capability the F-35 has over the F-16E. As an F-16 replacement platform, the F-35 will be able to carry more and go further. Of course, many of the F-35's Air-to-Ground capabilities involve carrying external ordnance—an aspect of aircraft development still awaiting testing.

While the F-35 has yet to prove many of its designed Air-to-Ground capabilities, the Silent Eagle platform is ready and proven with all of the ordnance capacity listed in Figure 12. Although the F-35's planned ordnance capacity is an increase over the F-16E's, the F-15SE still has a great payload advantage in several arenas. First, the Silent Eagle has more than twice the carrying capacity of the F-35 for medium-weight munitions, which are typically employed against fielded artillery, small structures, or personnel in the open. With precision-guided munitions, this means the Silent Eagle can

effectively destroy double the number of targets the F-35 can. Second, the F-15 specializes in heavyweight munitions, carrying five with external fuel or seven without external fuel. Although the F-35 can come close to these numbers (four with external fuel or six without), carrying this many weapons limits the F-35's Air-to-Air missile load to two missiles while the F-15SE can still carry four. The added missile load makes the F-15SE a more formidable platform executing opposed Air-to-Ground roles.

In addition to the amount of ordnance it can carry compared to the F-16E and F-35, the F-15SE also has superior combat radius. From a tactical perspective, superior radius is not only about range, but ability to loiter over a target area. Since Operation Desert Storm (ODS), the F-15E platform has routinely proven the importance of both range and loiter time for a fighter platform. In ODS, F-15Es were the only fighter platform with the range to conduct critical SCUD-hunting missions in the Northwest corner of Iraq.[50] Later in the same conflict, F-15Es were able to loiter over the vaunted Iraqi Republican Guard, in some instances destroying up to 16 pieces of Iraqi armor with a single 2-ship.[51] Today in Operation Enduring Freedom (OEF), fully loaded F-15Es routinely stay over a target area for two hours without refueling, approximately 45 minutes longer than an F-16 or F-35 can. Added loiter time increases the chances of finding and tracking targets and provides persistent effects to the ground commander.

The F-15SE as a Bomber Supplement

The F-15SE's distinctive capabilities in range, payload, and loiter make it a true medium-range fighter-bomber instead of a light attack aircraft. Given the uncertainty of the Air Force's future bomber fleet, acquiring the F-15SE would ensure the Air Force retained at least a medium-range bomber option past the year 2035. Obviously, no

fighter platform will have the intercontinental range of current or future bombers. From a payload perspective, however, the F-15SE gives relatively equal the weapons-delivery capability. A four-ship of F-15SEs, for example, can carry 20 GBU-31 heavyweight Joint Direct Attack Munitions (JDAMs), while a B-1 bomber can carry 24.[52] This means for medium-range missions, the Air Force can use F-15SEs for heavy strike instead of bombers. Having F-15SEs in the inventory allows the Air Force to focus the next-generation bomber acquisition around intercontinental deep strike, and reduce the overall number of bombers required. Focusing mission requirements and reducing numbers for the NGB platform should ultimately reduce the cost of the future bomber fleet.

Analysis of Evaluation

Evaluated against the three CBO options for filling the fighter shortfall, "Alternative 15SE" provides the Air Force with a capability-specific solution. Importantly, the acquisition price of the Silent Eagle and its O&S costs are more comparable to the F-35 than the F-16E. Therefore, if the Air Force's ultimate goal is simply to produce 2,200 fighters, the F-16E is a more cost-effective option. On the other hand, evaluating the F-15SE against the F-16E shows the Silent Eagle's dramatic capability differences giving combatant commanders unique options in future combat scenarios. If the Air Force chooses not to acquire the F-15SE, its future 5th-generation fighter force will be more range-limited and payload limited than today's force.

When evaluating the F-15SE against the F-35, one of the most important considerations is the unknown costs and capabilities still plaguing the F-35 program. The background of the F-35 program in the last decade shows a trend toward increased costs and uncertain capability. On the other hand, the F-15SE's distinctive capabilities in range and payload have already been proven at a known cost on the F-15E platform. By exchanging 270 F-35s for 270 F-15SEs under "Alternative 15SE," the Air Force would acquire known capabilities at a known cost. In addition, "Alternative 15SE" would help the Air Force mitigate acquisition concerns for the design of the Next-Generation Bomber by providing a medium-range strike solution out to the year 2065. Having this solution allows the Air Force to focus its NGB acquisition on intercontinental strike, leaving in-theater bombing entirely to the fighter force.

Conclusion

Although the Air Force continues toward acquiring an all-5th generation fighter force, the rapidly rising costs and capability unknowns of the F-35 make alternative solutions seem increasingly attractive. Of the "Generation 4.5" fighters available to supplement the F-35, the F-16E and the F-15SE "Silent Eagle" are both viable options. When analyzed from the perspective of combat capability, the Silent Eagle's distinctive characteristics make it the superior choice to the F-16E.

In Air-to-Air combat, the F-15SE outmatches both the F-35 and the F-16E in speed, range, and missile load. Although not a truly stealthy platform, the F-15SE's performance envelope will better enable mixed-force operations with the F-22 than the F-16E. In Air-to-Ground combat, the F-15SE's superior payload, range, and ordnance options allow it to execute missions even the F-35 cannot—missions also giving the Air Force a medium-range bomber capability from a fighter platform. These capabilities make it a distinctive choice over the F-16E.

The Air Force cannot cost-effectively *fill* the fighter shortfall by simply acquiring the F-15SE to complement the anticipated full purchase of 1,763 F-35s. Instead, the Air Force can *address* the fighter shortfall by acquiring about 270 F-15SEs in place of 270 F-35s. Making this change in the future fighter force structure would mitigate the lingering unknowns in the F-35 program by giving the USAF a proven fighter platform on a known timeline, with known cost savings. Most importantly, it would assure the USAF fighter force's capacity to provide the same breadth of combat capability it does today.

The F-15SE is the best choice to supplement the F-22 and F-35 based on the distinctive capabilities it provides in both Air-to-Air and Air-to-Ground combat.

Endnotes

(All notes appear in shortened form. For full details, see the appropriate entry in the bibliography.)

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[3] Defense Acquisition Management Information Retrieval (DAMIR), *F-35 Selected Acquisition Report,* 10.
[4] Ibid., 10.
[5] Ibid., XVII.
[6] Jeremiah Gertler, *Air Force Next-Generation Bomber: Background and Issues for Congress*, Congressional Research Service Report, 7.
[7] *Alternatives for Modernizing U.S. Fighter Forces,* 42.
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[22] Ibid., 31.
[23] Ibid., 30.
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[29] Ibid., 4.
[30] *F-35 Selected Acquisition Report,* 10.
[31] *Alternatives for Modernizing U.S. Fighter Forces,* 17.
[32] *Air Force Next-Generation Bomber: Background and Issues for Congress,* 11.
[33] Ibid., 16.

[34] Ibid., 16.
[35] Gen Norton A. Schwartz, *United States Air Force Posture Statement*, 1.
[36] *Alternatives for Modernizing U.S. Fighter Forces*, 53.
[37] Ibid., 54.
[38] Ibid., 70.
[39] Ibid., 46.
[40] *F-35 Selected Acquisition Report*, 38.
[41] Col Todd S. Bakita, *The USAF Fighter Force Structure in the 2020-2040 Timeframe, 21*.
[42] *Alternatives for Modernizing U.S. Fighter Forces*, 56.
[43] Ibid., 42.
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[45] *Alternatives for Modernizing U.S. Fighter Forces*, 30.
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