Congressional CBO Budget Office
Summary

Alternatives for Modernizing U.S. Fighter Forces

The United States Air Force, Navy, and Marine Corps maintain an inventory of approximately 3,500 fixed-wing fighter and attack aircraft that provide unsurpassed air-to-air and air-to-ground combat capabilities. Most of those aircraft were purchased at high annual rates during the 1980s, however, and are expected to reach the end of their service life at similarly high rates over the next decade. To counteract those impending retirements and simultaneously modernize their fleets, the service branches have outlined acquisition plans for equipping their force structures with new aircraft over the next 25 years. Specifically, the Air Force plans to replace the A-10 Thunderbolt II, the F-16 Fighting Falcon, and the F-15 Eagle with two types of aircraft: the F-22 Raptor and the F-35A Lightning II, the land-based version of the Joint Strike Fighter (JSF).[1] The Navy and Marine Corps plan to replace the AV-8B Harrier and F/A-18A/B/C/D Hornet with three types of aircraft: the F/A-18E/F Super Hornet; the F-35B, the short takeoff vertical landing version of the JSF; and the F-35C, the carrier-based version of the JSF.

The F-22 and F/A-18E/F are in active service today, but production of those aircraft is slated to end in 2011 and 2014, respectively. Development of the F-35 began in the 1990s, and initial production began in 2007. The services' schedules call for the first squadrons of F-35s to be operational in the Marine Corps, Air Force, and Navy by 2012, 2013, and 2015, respectively. Procurement is expected to continue through 2025 for the F-35B/C and through 2034 for the F-35A.

Those procurement plans notwithstanding, the Air Force and Navy have projected that, as laid out in fiscal year 2009 plans developed by the previous Administration, the rate of fighter production over the next 25 years would be insufficient to keep pace with the rate at which aircraft in current inventories would wear out and need to be replaced. As a result, the services are warning of an approaching "fighter gap" after 2015, when inventories of fighter aircraft are expected to drop below the levels needed to equip their planned force structures. That shortfall could be exacerbated by other issues that might arise. For example, production rates of the JSF might need to be reduced if unit costs increase; production of JSFs might be delayed if further technical problems arise in its development; or unanticipated problems with today's older aircraft might require that they be removed from service earlier than expected.[2]

This Congressional Budget Office (CBO) study looks at the composition of today's fighter fleets and at how the Department of Defense's (DoD's) plans for modernizing fighter forces—as set forth in the Bush Administration's 2009 Future Years Defense Program (FYDP) and other DoD documents—would affect inventories and war-fighting capability over the next several decades. (Just prior to the publication of this report, the Obama Administration released its budget request for fiscal year 2010. Summary Box 1 describes the proposed program changes that are relevant to this study.) As part of its analysis, CBO assessed the overall cost of executing DoD's fiscal year 2009 procurement plans. In addition, CBO explored seven alternative approaches to modernization that, in comparison with DoD's fiscal year 2009 projections, would offer varying levels of war-fighting

1. These aircraft are briefly described in Chapter 1. More detailed descriptions of their functions and capabilities can be found on the services' Web sites (www.af.mil/factsheets/; www.navy.mil/navydata/fact.asp, and http://hqinet001.hqmc.usmc.mil/AVN/documents/aircraft/fixedwing/fixedwing.htm) and at www.jsf.mil.

2. The inventory shortfalls projected by the services are due in part to delays that have already been experienced by the JSF program; those delays are largely attributable to the challenges of developing three aircraft around a common airframe.

Summary Box 1.

Implications of the New Administration's Fiscal Year 2010 Plans for Modernizing Fighter Forces

The analysis presented in this report is based largely on the Department of Defense's (DoD's) modernization plans for tactical aircraft as outlined in the Fiscal Year 2009 Future Years Defense Program (FYDP), which the Bush Administration submitted to the Congress in conjunction with its fiscal year 2009 budget request. In early April 2009, Secretary of Defense Robert M. Gates outlined a series of changes to those plans—several of which involve programs for modernizing tactical aircraft forces—that he recommended be incorporated in the Obama Administration's fiscal year 2010 defense budget request. The Office of Management and Budget released the 2010 request shortly before CBO published this report. However, the budget request did not contain sufficient programmatic details to allow CBO to conduct a complete reassessment of the modernization plans for U.S. tactical fighter forces. Moreover, DoD's comptroller announced that, unlike previous budget requests, the fiscal year 2010 request would not be accompanied by a FYDP, which would have supplied programmatic details for the out-years.

CBO determined that its analysis would be largely unaffected by the changes that Secretary Gates announced as part of DoD's proposed fiscal year 2010 plans for tactical aircraft forces. Three of DoD's changes were, nevertheless, directly relevant to CBO's comparison of DoD's fiscal year 2009 plans with the alternative modernization plans described fully in Chapter 3 of this report:

- First, the new budget proposes retiring 250 of the oldest Air Force tactical fighters in fiscal year 2010. In CBO's projection (based on fiscal year 2009 plans), the retirement of the 250 oldest Air Force fighters—as measured by the fraction of service life expended—would occur between 2010 and 2014. Consequently, the Air Force's inventory of legacy fighter aircraft and the weapons capacity they provide would be lower than CBO's projection from 2010 until 2014, at which time the inventory of legacy aircraft should come back into alignment with CBO's projection.

- Second, Secretary Gates stated that DoD plans to buy 513 F-35 Joint Strike Fighters (JSFs) over the five-year defense plan, about 160 more jets over the 2010–2014 period than indicated in fiscal year 2009 plans. That acceleration in production is similar to the increase of 132 F-35s postulated in the first of the alternative modernization plans CBO describes in this study. Those additional aircraft would offset somewhat the early retirement of older Air Force fighters. Unlike the provisions of CBO's Alternative 1, however, which would increase total production of F-35s to over 2,600 aircraft, DoD's total planned production of JSFs would remain at 2,443 aircraft.

- Third, Secretary Gates indicated plans to increase the procurement and use of Predator-class unmanned aerial vehicles. Although presented in the context of increasing intelligence, surveillance, and reconnaissance capabilities, those aircraft could be armed and used to augment strike capabilities, as postulated in two of the alternatives (Alternatives 5 and 7) examined in this report.

capability and require varying levels of financial commitment. The study makes no judgments about the affordability or sufficiency of DoD's fiscal year 2009 plans or the seven alternatives. CBO's analysis points to several general conclusions:

- If realized, the services' *goals* for modernizing their fighter forces over the next several decades would result in a significant increase in capability over that offered by today's forces. Inventories would remain about the same, but the modernized fleets would be equipped with state-of-the-art aircraft that offer substantial technological advances over today's fighters, including increased payload capacity and greater stealth capabilities (and, as a result, enhanced survivability). Notwithstanding DoD's emphasis on fielding aviation forces with greater flight endurance, the distance that newer aircraft could fly without requiring refueling ("unrefueled ranges") would not increase to the same extent.[3]

- Under DoD's fiscal year 2009 procurement *plans*, fighter inventories are likely to fall below the services' stated goals in the coming years. Nevertheless, many aggregate capabilities would remain equal to or improve relative to today's force because of the enhanced lethality and survivability that is expected from the new fighters. Some of those improvements might be offset by the increased capabilities of potential adversaries, however.

- Alternative approaches that included purchasing additional F/A-18E/F Super Hornets or purchasing upgraded versions of so-called legacy aircraft—such as the F-16 Fighting Falcon and F-15E Strike Eagle, which are still in production but based on older designs—would offer an opportunity for short-term inventory relief, long-term cost savings, or both, albeit with lesser capability improvements (especially in terms of survivability) than would be realized by purchasing JSFs.

- Compared with forces equipped solely with fighter aircraft, forces equipped with a mix of fighters (which are designed for supersonic speed and high maneuverability) and subsonic attack aircraft (designed, instead, to carry large payloads over long distances) would offer improved basing flexibility and persistence over the battlefield during air-to-ground missions. Force structures that replaced some fighters with smaller numbers of attack aircraft could provide air-to-ground weapons capacities comparable to those of today's forces and be fielded at costs similar to those projected for DoD's plans. Such forces would have fewer aircraft capable of air-to-air combat, however.

The Department of Defense's Fiscal Year 2009 Plans for Modernizing Fighter Forces

As articulated in the 2009 Future Years Defense Program and other DoD documents, such as the Selected Acquisition Reports, funding to modernize U.S. fighter forces over the 2010–2034 period would average over $8 billion per year in 2009 dollars. Most of that funding would be for the JSF. During the period of highest annual production of the JSF—currently projected to run from 2015 through 2022, when DoD plans to purchase 130 aircraft per year—funding would average over $10 billion per year.[4] Orders for what could be the final F-22s to be produced were placed in 2009, and final orders for the F/A-18E/F were planned for 2012. Production of both aircraft could be extended, however.

Plans for Fighter Inventories

Today, the Air Force's fighter inventory is higher than its stated goal of 2,200 aircraft. However, the Air Force anticipates that, by 2017, its inventory will drop below that level because the rate at which certain aircraft (primarily F-16s and F-15s) will reach the end of their service life will exceed the rate of production—80 aircraft per year—planned for F-35As (see the left panel of Summary Figure 1). CBO estimates that, under its base-case assumptions—production of the F-35A proceeds as laid out in DoD's fiscal year 2009 plans, today's Air Force fighters accumulate flight hours at past rates, and

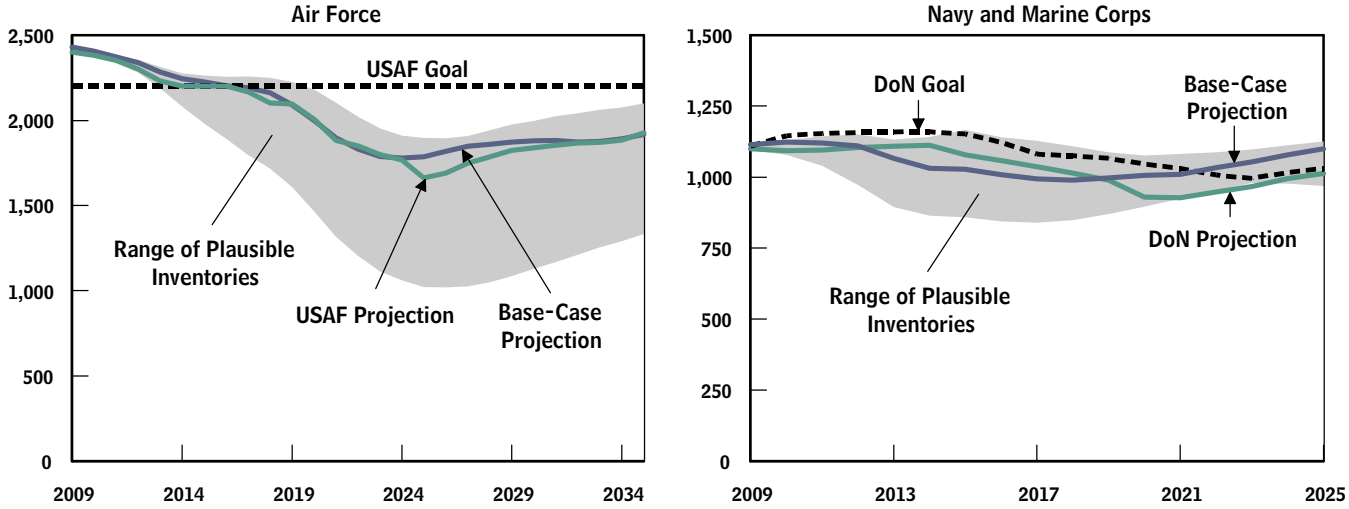
3. Greater flight endurance is of interest to DoD because it allows aircraft to remain aloft for longer periods of time with less reliance on aerial refueling tankers. The increased time aloft can be used to reach targets over longer distances or to increase persistence—the amount of time a plane can loiter over a location close to where it might be needed.

4. Production for the U.S. military would decrease after 2022 as purchases for the Navy and Marine Corps began to wind down. Under DoD's fiscal year 2009 plans, the only U.S. orders after 2025 would be for F-35As for the Air Force. Continuing sales to foreign governments are anticipated at that time, however.

Summary Figure 1.

Potential Fighter Inventories Under a Range of Projections

(Total aircraft inventory)



Source: Congressional Budget Office based on the Department of Defense's fiscal year 2009 plans.

Notes: DoN = Department of the Navy; JSF = Joint Strike Fighter; SLEP = Service Life Extension Program; USAF = United States Air Force.

Air Force:

Base-Case Projection:

- The A-10 and F-15 reach 16,000 and 12,000 flight hours, respectively
- Production and fielding of the F-35A JSF remain on schedule
- Average annual flight hours accrued per aircraft equal those of the past 10 years

Optimistic Case (Upper edge of shaded region):

- The A-10 and F-15 reach 16,000 and 12,000 flight hours, respectively
- Production and fielding of the F-35A remain on schedule
- Average annual flight hours accrued per aircraft are reduced by 10 percent (relative to the average of the past 10 years)

Pessimistic Case (Lower edge of shaded region):

- The A-10 and F-15 reach 12,000 and 8,000 flight hours, respectively
- Production of the F-35A slips by two years and peak production is reduced from 80 aircraft per year to 64
- Average annual flight hours accrued per aircraft equal those of the past 10 years

Navy and Marine Corps:

Base-Case Projection:

- F/A-18A/B/C/Ds reach 8,500 flight hours
- Average annual flight hours accrued for F/A-18A/B/C/Ds equal 325 hours per aircraft
- AV-8B Harriers are retained through 9,500 flight hours
- Production of the F-35B/C JSF remains on schedule

Optimistic Case (Upper edge of shaded region):

- F/A-18C/Ds reach 10,000 flight hours (including an as-yet-unfunded SLEP)
- Average annual flight hours accrued for F/A-18A/B/C/Ds equal 325 hours per aircraft
- AV-8Bs are retained through 9,500 flight hours
- Production of the F-35B/C remains on schedule

Pessimistic Case (Lower edge of shaded region):

- F/A-18A/B/C/Ds reach 8,000 hours
- Annual flight hours accrued for F/A-18A/B/C/Ds equal 420 hours per aircraft
- AV-8Bs are retired as F-35Bs are delivered
- Production of the F-35B/C slips by two years

unforeseen problems do not ground today's aircraft sooner than is currently anticipated—the Air Force's shortfall relative to current requirements will peak in about 2025 at over 400 aircraft and then begin to decrease thereafter. The shaded regions in the figure illustrate a range of inventories that could be realized under a variety of alternative assumptions—both optimistic and pessimistic—about the JSF's rate of production and the service life of today's aircraft.[5] The Air Force's projections are similar to CBO's, although some officials have questioned whether procuring 80 F-35As per year will be achievable under anticipated budget constraints. According to CBO's estimates, by 2035, DoD's fiscal year 2009 plans—including extending the service life of some existing aircraft and purchasing 187 F-22s and 1,763 F-35As—would yield an inventory that was about 200 aircraft short of the Air Force's goal.

The Navy's and Marine Corps' inventory today is close to the stated goal of 1,110 aircraft.[6] The services' fiscal year 2009 modernization plans called for the purchase of a total of 506 F/A-18E/F Super Hornets (over 380 had been delivered as of February 2009) and 680 F-35B/C JSFs over the 2008–2025 period. The exact mix of F-35Bs and F-35Cs has not yet been determined by the Navy and Marine Corps. Although that total quantity would be sufficient to meet the Navy's and Marine Corps' inventory goals when production of the F-35B/C ends in 2025, the Navy projects a shortfall in the interim as F/A-18A/B/C/D Hornets and AV-8B Harriers are retired (see the right panel of Summary Figure 1). According to the Navy's estimates, that shortfall will peak at about 125 aircraft in 2017.

CBO projects somewhat greater shortfalls for the Navy and Marine Corps through 2018 because it assumed that extending the service life of F/A-18A/B/C/Ds beyond 8,500 flight hours, which the Navy proposes, could prove to be impractical. (The Navy's projection assumes that, with modifications, Hornets could reach 10,000 flight hours. However, such a program is not currently funded, and there is considerable uncertainty as to whether it will be practical to implement the necessary modifications.) CBO's estimates for the years following 2018 indicate a lower shortfall than the Navy and Marine Corps projected because CBO assumed that, instead of being retired as F-35s are delivered to the Marine Corps, AV-8Bs would be retained as long as they were flightworthy. If production of the JSF is further delayed, the Navy's and Marine Corps' fighter inventory could dip significantly lower than the services projected (see the lower edge of the shaded region in the right panel of Summary Figure 1). Alternatively, if the Hornet proved to be more robust than the Navy currently expects, and if efforts to manage fleet usage meet with success, inventory shortfalls could be less severe than expected.

Capabilities Offered Under Fiscal Year 2009 Plans

Although fiscal year 2009 fighter modernization plans could result in inventory shortfalls relative to the services' stated requirements, aggregate fleet capabilities could nevertheless improve in many respects because the JSF is expected to perform significantly better than the aircraft it is meant to replace. CBO developed several performance metrics that allow comparisons between the capabilities of today's fighter forces and those envisioned under DoD's plans. On the basis of those comparisons, CBO determined that many air-to-ground and air-to-air capabilities would improve relative to today's even during periods with inventory shortfalls (see Summary Figure 2). The capabilities shown in the figure correspond to CBO's base-case inventory projections shown in Summary Figure 1.

The air-to-ground weapons capacity of the Air Force's fighter force—as measured by the fleet's aggregate capacity to carry 2,000-pound, satellite-guided Joint Direct Attack Munitions (JDAMs)—would increase substantially under fiscal year 2009 plans because the F-35A is designed to have larger payload capacity and somewhat longer flight ranges than the F-16 Fighting Falcons it is slated to replace and because the F-15C/D Eagles it is intended to replace are strictly air-to-air fighters. For example, relative to today, the fleet's aggregate capacity to deliver JDAMs when operating in a nonstealthy configuration (with weapons carried by the F-35A both internally and externally) would increase by over a factor of

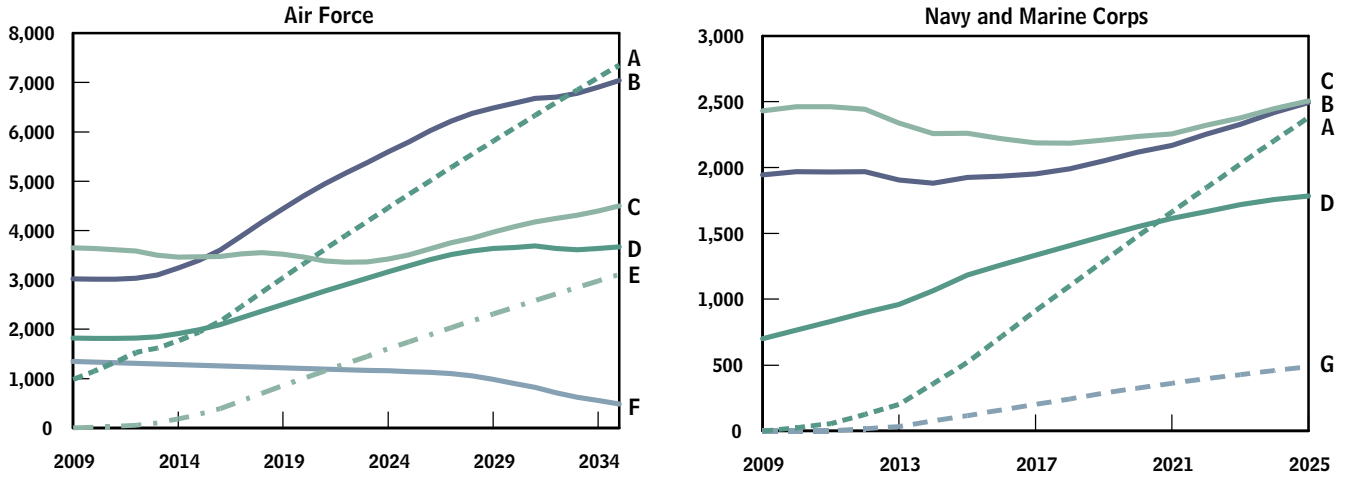
5. Although they do not strictly represent "best-case" or "worst-case" inventory scenarios, the shaded regions in Summary Figure 1 incorporate a wide range of assumptions—from very optimistic to very pessimistic—that have been put forth by the services or other analysts. Not included are the implications of large changes in funding or requirements that could be made in the future.

6. This report does not consider tactical fighter aircraft specialized for airborne electronic attack—in particular, the EA-6B and its replacement, the EA-18G—in its discussion of inventory goals. The Navy's and Marine Corps' inventory goals change slightly over time as the composition of their forces evolves. The number of squadrons would remain unchanged.

Summary Figure 2.

Changes in the Weapons Capacity of Fighter Forces Under DoD's Fiscal Year 2009 Modernization Plans

(Number of weapons)



Source: Congressional Budget Office based on the Department of Defense's (DoD's) fiscal year 2009 plans.

Notes: JDAM = Joint Direct Attack Munition; n. mi. = nautical miles.

Estimates of mission range are based on the distance an aircraft could fly from an aerial refueling orbit.

For air-to-ground missions, weapons capacity is based on loads of 2,000-pound JDAMs.

For air-to-air missions, weapons capacity is based on aircraft-specific loads of AIM-9 and AIM-120 missiles.

Stealth-only capacity (dashed lines) indicates that weapons are carried exclusively in internal bays. Total capacity (solid lines) indicates that weapons are carried both in internal bays and on external weapons racks.

Mission type (air-to-ground or air-to-air)/Weapons carriage (stealth-only or total)/Mission radius (air-to-ground missions only):

A = Air-to-air/Stealth-only

B = Air-to-ground/Total/500 n. mi.

C = Air-to-air/Total (divided by 4)

D = Air-to-ground/Total/600 n. mi.

E = Air-to-ground/Stealth-only/600 n. mi.

F = Air-to-ground/Total/700 n. mi.

G = Air-to-ground/Stealth-only and total/700 n. mi.

two for missions against targets located about 500 nautical miles (n. mi.) from the orbit of the nearest aerial refueling tanker.[7] As the service's inventory of F-35As began to grow, moreover, the fleet's aggregate capacity to deliver 2,000-pound JDAMs out to a radius of 500 n. mi. when operating in a stealthy configuration (with weapons carried only in the F-35A's internal weapons bay) would eventually—in about 2030—equal today's total capacity and continue to increase in subsequent years. The air-to-ground strike capacity of Air Force fighters at ranges of 700 n. mi. and farther would decrease under fiscal year 2009 plans, though, because at that range the F-35A cannot replace the capacity provided by F-15Es and A-10s, which will begin to be retired from service after 2025.

7. The mission radii cited in this report are distances from an aerial refueling orbit. Mission radii from a land base, aircraft carrier, or amphibious ship would be shorter because additional fuel is consumed while taking off and climbing to altitude. The range estimates are limited to external fuel tanks typically used by the U.S. military. Longer ranges might be possible with larger tanks.

The air-to-ground capacity of the Navy's and Marine Corps' fleets would also be higher than today's, even during periods of inventory shortfall. However, the increases in air-to-ground capacity (as measured by the capacity to carry 2,000-pound JDAMs) would be less substantial than those experienced by the Air Force because all aircraft being replaced are air-to-ground capable (unlike the F-15C/D) and because the F-35B will be unable to carry 2,000-pound weapons in its internal weapons bay.

In addition to weapons capacity, other aspects of the modernized force would offer enhanced strike capability in the future. For example, new air-to-ground weapons are expected to result in greater lethality for a given aircraft payload. In particular, the 250-pound Small Diameter Bomb (SDB) that has recently been fielded by the Air Force is expected to provide current and future aircraft with the ability to destroy more targets per sortie than is possible with today's weapons. More-capable communications systems and radars—for example, radars with active electronically scanned array (AESA) antennae in place of older, mechanically scanned antennae—are expected to improve the ability to detect and identify targets both in the air and on the ground. In areas with strong air defenses, the stealth characteristics of the JSF will enable greater freedom of action for strike forces early in a conflict before those defenses can be destroyed.[8]

Improved radars and stealth airframes will also enhance fighter jets' air-to-air capabilities relative to those of today's force. The move to AESA radars will enable the new fighters to detect enemy aircraft at longer ranges while stealth features will reduce an enemy's corresponding capability. The capacity to carry air-to-air missiles in a stealthy configuration (with all weapons in internal bays) would markedly increase under DoD's fiscal year 2009 modernization plans as JSFs and the final F-22s entered the force. Total air-to-air missile capacity, which includes provisions for external missile carriage on the F-22 and JSF, would remain about the same as today's capacity, although internal carriage would be preferred for the F-22 and JSF in order to fully maintain their stealth characteristics.

8. Some of the improvements in survivability offered by stealth capability and by more-advanced onboard systems would be offset, however, if potential adversaries fielded more-effective defensive systems.

Alternative Approaches for Modernizing Fighter Forces

DoD's fiscal year 2009 modernization plans have led to calls for increased production of fighter and attack aircraft (from those who believe that satisfying inventory requirements is of primary importance) as well as calls for decreased or deferred production (from those who believe that the capability improvements offered by new aircraft can compensate for lower inventories). In the course of its analysis, CBO examined seven alternative plans for modernization, which can be grouped into three general categories:

- Those that would accelerate and increase purchases of fighters to maintain inventories equal to service-defined requirements—essentially eliminating any fighter gaps (Alternatives 1 through 3);
- Those that would result in smaller inventories but maintain aggregate weapons capacity at least at today's levels (Alternatives 4 and 5); and
- Those that would allow inventories of manned fighters to shrink but would replace some lost capabilities with either medium-range bombers or unmanned attack aircraft (Alternatives 6 and 7).

Each general approach could be implemented in a wide variety of ways other than CBO's illustrative alternatives, and combinations of approaches would also be possible.[9]

Approaches That Satisfy the Services' Current Inventory Goals

Under Alternatives 1 through 3, DoD would not only purchase additional aircraft, but would also purchase those planes earlier than fiscal year 2009 plans stipulate to avoid inventory shortfalls relative to the services' stated requirements. Projected shortfalls would be eliminated under Alternative 1 by purchasing 164 more F-35As for the Air Force and shifting purchases of the JSF for all the services to earlier years.[10] For Alternative 1 to be feasible,

9. For example, one approach might maintain weapons capacity for the Air Force and Marine Corps and inventory level for the Navy.

10. Because development of the JSF has not been completed, CBO assumed that peak production rates would be increased to higher levels than planned but that the ramp-up to those levels would proceed as currently scheduled. The higher production rates are within the planned capacity of Lockheed Martin's assembly facilities.

Summary Box 2.

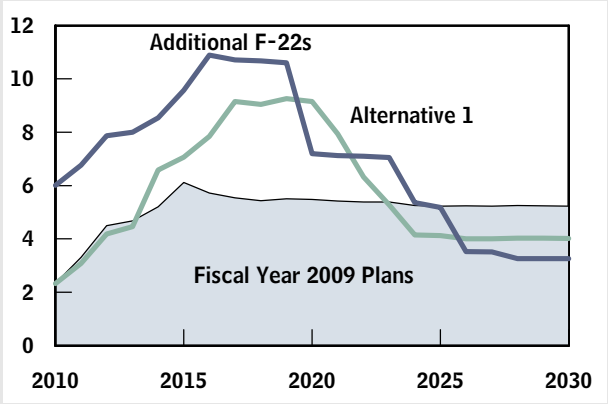
The Possible Role of the F-22 Program in Mitigating the Air Force's Projected Inventory Shortfall

Instead of increasing the number of F-35A Joint Strike Fighters procured over the 2010–2034 period and accelerating the pace at which those jets are purchased—as the Congressional Budget Office (CBO) outlined in the first of seven alternatives to the Department of Defense's (DoD's) fiscal year 2009 fighter modernization plans—the Air Force could eliminate the projected shortfall in its fighter inventory and still build an all-stealth fighter force by continuing to purchase F-22 Raptors. CBO estimates that the Air Force could maintain an inventory of 2,200 aircraft by purchasing 200 more F-22s at a rate of 20 per year from 2010 through 2019 and by shifting purchases of 240 F-35As from the 2025-2034 period to the 2016-2023 period.[1] (Total purchases of the F-35A would decrease by 35 aircraft, from the planned 1,763 to 1,728.)

That modernization approach would require significantly greater resources in the coming years, however, because continued production of the F-22 would coincide with early, large-scale production of the F-35A, when unit prices are the highest (see the figure above). Under that approach, about $37 billion would be needed between 2010 and 2014 (compared with about $20 billion under DoD's fiscal year 2009 plans and under Alternative 1). About $157 billion would be needed through 2034, when final purchases of the F-35A are scheduled to be completed (as opposed to the $124 billion projected under fiscal year 2009 plans and the $130 billion estimated under Alternative 1).

Funding Needed by the Air Force Under DoD's Fiscal Year 2009 Plans Plus Two Alternatives

(Billions of 2009 dollars)



Source: Congressional Budget Office.

1. Funding for what were to have been the last 20 F-22s ordered by the Air Force was included in the fiscal year 2009 budget. In April 2009, DoD indicated that it would not include additional F-22s in its forthcoming budget request for fiscal year 2010. Funding for four F-22s, which would bring total procurement to 187 aircraft, was requested by the Administration in its proposed supplemental appropriation for fiscal year 2009, however.

development and fielding of the JSF could not experience additional substantial delays. (A variant of Alternative 1 that would include purchases of additional F-22s for the Air Force is described in Summary Box 2.) Under Alternative 1, CBO estimates, total investment costs—specifically, those for research, development, test, and evaluation (RDT&E) and for the procurement of new aircraft—would be $208 billion over the 2010–2034 period.[11] (See Summary Table 1.) Although the overall costs of implementing Alternative 1 would be only about $5 billion more than DoD's projections for total funding under fiscal year 2009 plans, costs over the next five years would increase by about $12 billion as a result of accelerating purchases of the JSF. Although the total investment costs estimated for Alternative 1 would be only about 2 percent higher than is projected for DoD's fiscal year 2009 plans when measured in constant dollars, Alternative 1 would be about 7 percent more costly when measured on a net-present-value basis (at a real discount rate of 3 percent) because of the shift in funding to earlier years.

11. The figures cited do not include RDT&E and procurement costs for continuing upgrades to existing aircraft.

Summary Table 1.

Costs of Fighter Aircraft Under DoD's Fiscal Year 2009 Modernization Plans and Seven Alternative Plans

Plan	Remaining Investment Costs (Billions of 2009 dollars) 2010–2014	Remaining Investment Costs (Billions of 2009 dollars) 2010–2034	Remaining Investment Costs (Billions of dollars, net present value) 2010–2014	Remaining Investment Costs (Billions of dollars, net present value) 2010–2034
DoD's Fiscal Year 2009 Modernization Plans	54	203	49	147
Alternative 1: Satisfy Inventory Requirements by Accelerating/Increasing Purchases of JSFs	66	208	59	157
Alternative 2: Satisfy Inventory Requirements by Purchasing JSFs and Improved Legacy Aircraft	71	211	64	160
Alternative 3: Cancel the JSF Program and Satisfy Inventory Requirements by Purchasing Improved Legacy Aircraft	44	154	39	117
Alternative 4: Purchase JSFs in Quantities to Match Weapons Capacity in 2009	53	136	48	105
Alternative 5: Purchase Enough JSFs to Match Weapons Capacity in 2009 and Satisfy Inventory Requirements by Purchasing Small, Armed UAVs	57	156	51	119
Alternative 6: Replace Some Fighter Aircraft with Medium-Range Bombers or UCAV-Ns to Improve Mission Range	64	200	58	153
Alternative 7: Replace Some Fighter Aircraft with Medium-Range Bombers or UCAV-Ns to Improve Mission Range and Augment Fleets with Small, Armed UAVs to Satisfy Inventory Requirements	67	220	61	165

Source: Congressional Budget Office based on the Department of Defense's (DoD's) fiscal year 2009 plans.

Notes: JSF = Joint Strike Fighter; UAV = unmanned aerial vehicle; UCAV-N = carrier-capable unmanned combat aerial vehicle.

Investment costs comprise expenses for research, development, test, and evaluation of new aircraft and for procurement of those aircraft.

Under Alternative 2, DoD would not purchase additional JSFs but would, instead, augment fighter inventories in the near term with purchases of new aircraft that are based on older designs; specifically, DoD would acquire 260 F/A-18E/Fs, in addition to those in the fiscal year 2009 plans, for the Navy and Marine Corps and 435 F-16Es for the Air Force.[12] Because of those purchases, 530 fewer JSFs would be produced in later years. According to CBO's estimates, investment costs under Alternative 2 would be $211 billion—$8 billion more than under DoD's fiscal year 2009 plans (or about 4 percent higher in constant 2009 dollars and 9 percent higher on a net-present-value basis) and $17 billion more over the next five years.[13]

Under Alternative 3—which CBO estimates would require an investment of about $154 billion—DoD would cancel the JSF program and modernize the fighter force by purchasing upgraded versions of aircraft that are based on older designs, including 680 F/A-18E/Fs, in addition to those already planned, for the Navy and Marine Corps and 1,925 F-16Es for the Air Force. In total, Alternative 3 would cost $49 billion less than is projected for DoD's fiscal year 2009 plans over the 2010–2034 period (about 24 percent less in constant dollars and 21 percent less on a net-present-value basis) and $10 billion less over the next five years, CBO estimates.[14]

12. Relative to the F-16C in today's fleet, the F-16E includes improved avionics, AESA radar, conformal fuel tanks for longer flight range, and a strengthened airframe for carrying larger payloads. The F-16E has been marketed to foreign militaries, and an earlier version (called the F-16 Block 60 at the time) was a modernization alternative considered by the Air Force prior to the selection of the JSF.

13. Alternative 2 would cost more than Alternative 1 because the decreased numbers of JSFs purchased would result in higher unit costs for that aircraft. The 530 JSFs not produced would be deleted from the end of the production run when unit costs would be the lowest.

14. U.S. cancellation of the JSF would most likely make it unaffordable for the program's international participants. (The United Kingdom, Norway, Denmark, the Netherlands, Canada, Italy, and Turkey have collectively contributed about $5 billion to the JSF's research and development thus far.) Depending on the contractual arrangements underlying that participation, the United States could decide to take some action (for instance, arranging for financial compensation) to help mitigate the consequences that canceling the program would have for them. Other modern fighters that could be purchased in lieu of the JSF, including both U.S. and European designs, are currently in production.

Approaches That Maintain Current Weapons Capacity

Alternatives 4 and 5 would result in smaller fighter inventories, but the aggregate air-to-ground weapons capacity for short-range missions—those within a radius of 300 n. mi. from an aerial refueling tanker—would be maintained at today's level. Under Alternative 4, purchases of the F-35A for the Air Force would be cut approximately in half, to 850 aircraft, and the Air Force's fighter inventory would, as a consequence, drop to about 1,200 aircraft when production of the F-35A ends in 2033. For the Navy and Marine Corps, 150 F-35Bs and 330 F-35Cs would be purchased under Alternative 4, and the inventory of fighters would drop to about 900 aircraft when the final F-35B/Cs were delivered in 2022. Those smaller purchases would result in significantly lower investment costs—a total of about $136 billion, CBO estimates, or about $67 billion less than the amounts indicated in DoD's fiscal year 2009 modernization plans (33 percent less in constant dollars and 29 percent less on a net-present-value basis). Savings would be only about $1 billion over the next five years, however, because CBO assumed that production of the JSF would initially ramp up as specified in fiscal year 2009 plans but level off at 90 per year (instead of 130 per year).

Under Alternative 5, purchases of relatively inexpensive armed unmanned aerial vehicles (UAVs) would be added to the fighters purchased under Alternative 4 to partially compensate for lower fighter inventories. Specifically, the Air Force would purchase nearly 1,000 MQ-9 Reapers. (The Reaper is a larger version of the Predator reconnaissance aircraft, which has generated much attention for attacking insurgent targets with Hellfire missiles during Operations Enduring Freedom and Iraqi Freedom.) Under this alternative, 151 Reapers—modified for carrier operations—would be purchased for use by the Navy or Marine Corps. Although they lack the speed and payload capacity of the typical fighter, those UAVs could fill an important role by orbiting over combat areas in order to be ready to rapidly respond to calls from ground forces for fire support. Investment costs under Alternative 5 would total $156 billion (23 percent less in constant dollars and 19 percent less on a net-present-value basis than is projected for DoD's fiscal year 2009 plans), or about $20 billion more than under Alternative 4. Costs over the next five years would be similar to those specified in DoD's fiscal year 2009 plans.

Approaches That Provide Greater Unrefueled Mission Ranges

Under Alternatives 6 and 7, DoD would replace some of the fighters that would be purchased under fiscal year 2009 plans with attack aircraft capable of undertaking longer-range missions—a capability that would increase both the range and endurance of U.S. strike forces. Under Alternative 6, the Air Force would field about 500 stealthy fighter aircraft—187 F-22s and 325 F-35As—and 250 stealthy medium-range bombers that would each be able to carry a payload of 10 2,000-pound JDAMs at high subsonic speeds out to a radius of 1,500 n. mi.[15] The Navy and Marine Corps would purchase 410 F-35B/Cs—270 fewer than planned—and 275 stealthy carrier-capable unmanned combat air vehicles (UCAV-Ns) that would be able to carry a load of two JDAMs weighing 2,000 pounds each out to a radius of 1,500 n. mi. Overall, implementing Alternative 6 would cost about $200 billion, CBO estimates, slightly less than the projected cost of fiscal year 2009 plans (about 2 percent less in constant dollars and 4 percent less on a net-present-value basis). However, because of expenses related to RDT&E for the new aircraft, costs over the next five years would be about $10 billion higher than those projected in DoD's fiscal year 2009 plans.

Under Alternative 7, Reapers would be added to the aircraft slated for purchase under Alternative 6—1,000 for the Air Force and 100 for the Navy—to round out inventories. The overall cost of implementing Alternative 7 would be about $220 billion, CBO estimates—or about 7 percent more in constant dollars and 13 percent more on a net-present-value basis.

Capabilities of Alternative Forces

All of the alternative fighter forces examined by CBO would provide greater capacity to deliver air-to-ground weapons than today's forces under most circumstances (see Summary Figure 3). For the Air Force, the payload capacity of the F-35A relative to that of the F-16C would result in about a threefold increase in weapons capacity for missions out to a radius of 500 n. mi. For all approaches analyzed by CBO—except for Alternative 3—the Air Force's weapons capacity while operating in a stealthy configuration would be close to or greater than today's total weapons capacity. Except for Alternatives 6 and 7, however, total weapons capacity at longer ranges (out to a radius of 700 n. mi. and beyond) would decrease. Alternatives 6 and 7 would offer the Air Force increased total weapons capacity (most of it stealthy) out to 700 n. mi. and beyond. (Total capacity at 700 n. mi. would decline under the other alternatives and under DoD's modernization plans as F-15Es were retired.)

The Navy and Marine Corps would show lesser improvement in total capacity at shorter ranges. However, the longer range offered by the F-35C, which is reflected in all but Alternative 3, would increase the Navy's unrefueled reach to a radius of 700 n. mi.; and the UCAV-Ns included in Alternatives 6 and 7 would extend the Navy's unrefueled mission radius to 1,500 n. mi. For the Air Force, Navy, and Marine Corps, improved weapons—such as the 250-pound SDB—would further increase future air-to-ground capabilities relative to today's. Alternative 3 would not include short takeoff vertical landing fighters for operation from amphibious ships, however.

All of the alternative forces examined by CBO would consist of aircraft with significantly improved systems relative to today's forces. At a minimum, under every alternative, today's conventional fleet would be replaced with a fleet made up almost entirely of stealthy aircraft or new conventional aircraft with more advanced avionics and radars (see Summary Figure 4).[16] In the alternatives considered by CBO, new aircraft based on older designs that incorporated advanced avionics and radars would provide greater air-to-ground and air-to-air effectiveness than do DoD's current aircraft; but those planes would not provide the same freedom to operate against strong air defenses that would be enjoyed by the stealth aircraft DoD plans to purchase. Under the alternatives that would procure reduced quantities of stealthy aircraft, an appropriate mix of stealthy and nonstealthy aircraft could be deployed early in a conflict and used to help suppress

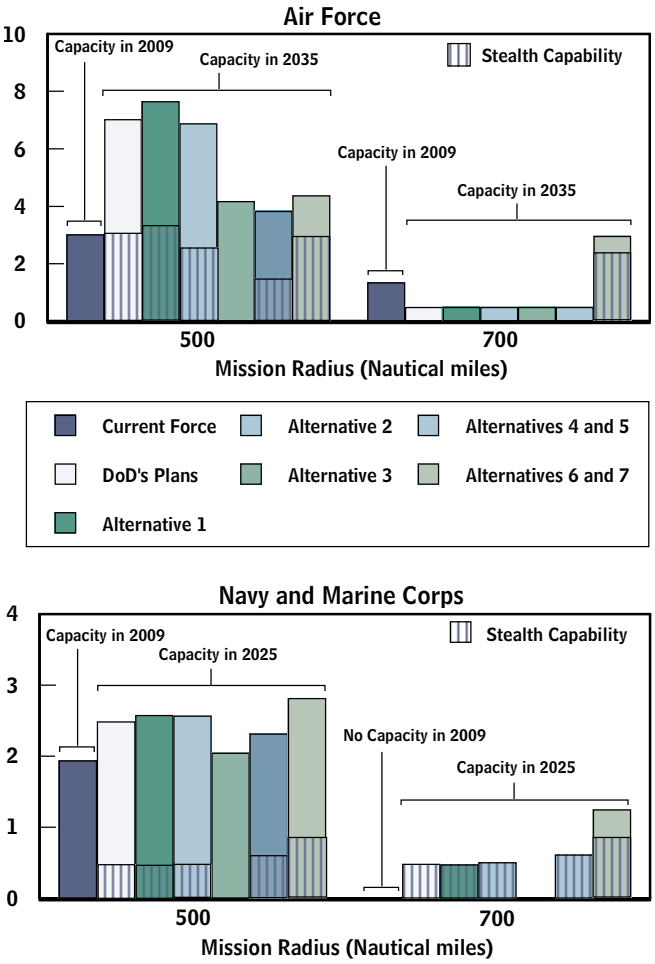
15. In addition to fighter aircraft, the Air Force also fields about 140 long-range bombers (B-52Hs, B-1Bs, and B-2As) that routinely contribute to conventional strike operations. CBO did not include those aircraft in its estimates of weapons capacity because many bombers are typically committed to other roles (such as nuclear deterrence) that are beyond the scope of this paper.

16. Avionics are the electronic systems and software that support various functions in aviation, including communications, navigation, flight control, collision avoidance, and so on.

Summary Figure 3.

Weapons Capacity of Fighter Forces Under DoD's Fiscal Year 2009 Plans and Seven Alternative Plans

(Thousands of 2,000-pound JDAMs)



Source: Congressional Budget Office.

Notes: DoD = Department of Defense; JDAM = Joint Direct Attack Munition.

Specific estimates of mission range reflect the distance an aircraft could fly from an aerial refueling tanker to a designated target and back with a fuel reserve of 30 minutes.

The years 2035 and 2025 correspond with the respective services' fiscal year 2009 plans for concluding production of the Joint Strike Fighter. After 2035 (or perhaps sooner), the Air Force will probably need to begin replacing or extending the service life of older F-22s. After 2025, the Navy will probably need to take similar measures for F/A-18E/Fs.

air defenses, clearing the way for subsequent operations by conventional aircraft.[17]

Under Alternatives 4 and 6, the Air Force would field a considerably smaller number of aircraft than would be fielded under fiscal year 2009 plans. The number of fighters operated by the Navy and Marine Corps would be only slightly smaller under Alternative 4. Although lower inventories could reduce the services' ability to operate in many places at once, fielding small and relatively inexpensive (when compared with the cost of a fighter) armed UAVs, such as the MQ-9 Reapers that are included in Alternatives 5 and 7, could potentially mitigate that shortcoming. In recent conflicts, fighters have been heavily tasked with remaining airborne and ready to respond at short notice to requests for air support. The success of the armed Predator aircraft illustrates that this type of mission can be successfully carried out with aircraft that lack the larger payloads and higher performance (and higher cost) of fighters.[18] Endurance, a shortcoming of fighter aircraft designed for high speed and maneuverability, can be more important than payload capacity in many circumstances.

Alternatives that would result in smaller aircraft inventories would most likely have lower operation and support costs than forces that maintain today's inventory levels. CBO did not estimate operation and support costs for the alternatives examined because there is considerable uncertainty about how expensive it will be to maintain the new generation of manned and unmanned aircraft. Recent operational experience with the F-22 and projections for the JSF suggest that those aircraft will be more

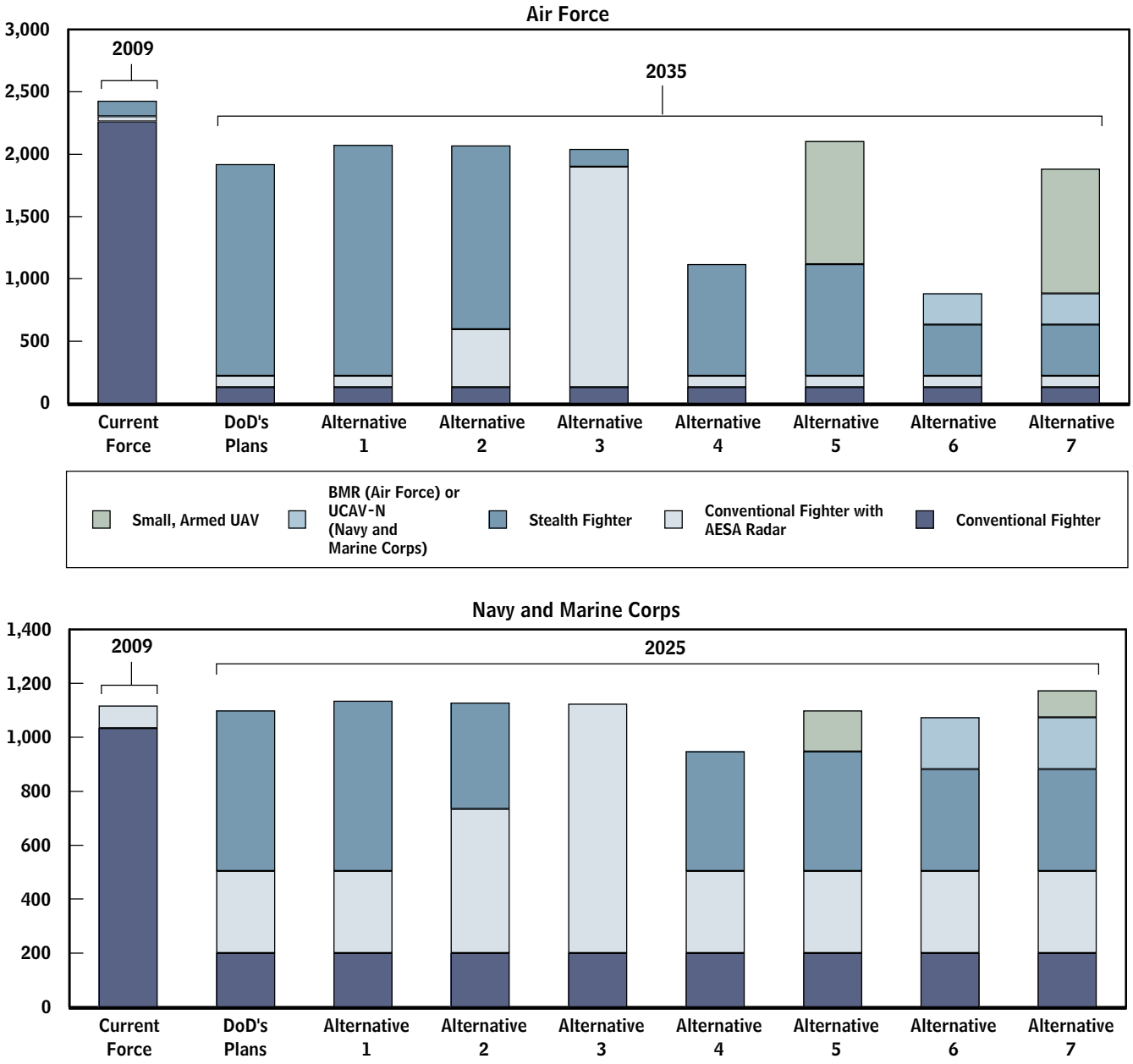
17. With aircraft such as the EA-6B and EA-18G, DoD anticipates conducting specialized airborne electronic attack (AEA) operations against advanced air defenses even when operating with stealthy aircraft, and some additional investment in AEA forces might be needed if DoD were to purchase larger numbers of conventional aircraft. Considerations of AEA capabilities in the options presented here are excluded, however, for the sake of simplicity and because detailed survivability discussions are best carried out at a classified level.

18. Predator and Reaper operations could be constrained by air defenses, however, and thus might not be possible early in a conflict against an adversary with advanced defenses (before those defenses could be otherwise suppressed). To provide fighter forces with greater capability in the face of air defenses, General Atomics is developing a stealthier version of the Reaper that could be purchased instead (although probably at a higher cost).

Summary Figure 4.

Composition of Fighter Inventories Under DoD's Fiscal Year 2009 Modernization Plans and Seven Alternative Plans

(Number of aircraft)



Source: Congressional Budget Office.

Notes: AESA = advanced electronically scanned array; BMR = medium-range bomber; DoD = Department of Defense; UAV = unmanned aerial vehicle; UCAV-N = carrier-capable unmanned combat aerial vehicle.

The years 2035 and 2025 correspond with the respective services' fiscal year 2009 plans for concluding production of the Joint Strike Fighter. After 2035 (or perhaps sooner), the Air Force will probably need to begin replacing or extending the service life of older F-22s. After 2025, the Navy will probably need to take similar measures for F/A-18E/Fs.

Today's inventories may be slightly different as a result of recent deliveries or retirements of aircraft.

expensive to operate and maintain than the aircraft they are replacing, however.[19]

The significantly longer unrefueled ranges achievable by the medium-range bombers and the UCAV-Ns envisioned for Alternatives 6 and 7 would help address DoD's concerns about so-called anti-access threats.[20] Access can be restricted not only by an adversary's air defenses (which stealth capability is designed to counter) but also under certain "denied-basing" scenarios—for instance, if local airbases are not made available for political reasons, if operations are conducted in remote areas that lack airbases, or if an adversary is able to attack bases used by U.S. forces or Navy carriers with long-range weapons. Longer-range aircraft can make it more practical to operate aircraft from bases outside the range of an adversary's weapons (or to keep aircraft carriers farther from shore where they are more difficult to locate and attack). Other advantages of long-range aircraft are that they offer the ability to attack targets farther into defended airspace where aerial refueling tankers are usually unable to operate and to loiter longer over target areas to provide persistent fire support. Purchases of the F-35B might also help address access limitations because those aircraft can be operated from large amphibious ships as well as from airbases that are smaller than needed by conventional land-based aircraft. That basing flexibility comes with the disadvantages of decreased mission range and payload capacity and increased costs, however.

19. A brief discussion of operation and support costs can be found in the appendix.

20. The 2006 Quadrennial Defense Review explicitly called for reorienting joint air capabilities toward "…systems that have far greater range and persistence; larger and more flexible payloads for surveillance and strike; and the ability to penetrate and sustain operations in denied airspace."