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CONGRESSIONAL BUDGET OFFICE

CBO

The Cost of Replacing Today's Naval Aviation Fleet

JANUARY 2020

Notes

The years referred to in this report are federal fiscal years, which run from October 1 to September 30 and are designated by the calendar year in which they end.

To allow comparisons with the Congressional Budget Office's earlier reports in this series on long-term aviation costs, all costs are expressed in 2018 dollars. To remove the effects of inflation, CBO adjusted costs with either the gross domestic product price index from the Bureau of Economic Analysis or with CBO's projection of that index.

On the cover: an F-35C Lightning II (top) and an F/A-18F Super Hornet (bottom).

Contents

The Cost of Replacing Today's Naval Aviation Fleet

Summary

The Department of the Navy's current aviation fleet consists of about 4,000 aircraft. Approximately 1,400 are fixed-wing fighter/attack aircraft, another 1,350 are helicopters or tiltrotor aircraft, and 750 are training aircraft.[1] The remainder are surveillance, communication, cargo, or utility aircraft. In this report, the Congressional Budget Office projects the costs that the Department of the Navy—which comprises the Navy and the Marine Corps—would incur to maintain the size and composition of that force through 2050. The projections are based on the assumption that the department will implement its currently planned aircraft procurement programs and replace aircraft for which it has not yet specified plans at the end of their typical service life.[2] The projections do not take into account the costs of development, operation and maintenance, modifications, or personnel associated with aircraft.

CBO projects that purchasing new aircraft to maintain the current size of the naval aviation fleet would cost the federal government about $380 billion (in 2018 dollars) from 2020 to 2050.[3] According to CBO's findings:

- Annual costs for procuring new aircraft through 2030 would average about $11 billion, an amount similar to the average since 2000. Costs would drop temporarily after 2030 as several large programs—the MV-22B tiltrotor, the CH-53K helicopter, and the F-35B/C fighters—began to wind down or ended. That would mark the completion of a nearly total replacement of the fleet over the past 30 years.

- Costs would rebound in the mid-2030s as the next cycle of replacement started, including initial purchases of aircraft to replace the F/A-18E/F and EA-18G fighters and early-production MV-22Bs. Costs would average about $14 billion per year from 2034 through 2050.

- The replacement of fighter/attack aircraft would represent the largest fraction of overall costs from 2020 through 2050, totaling about $190 billion, roughly half of the total for all aircraft.

CBO's projections of procurement schedules and costs are based on documents from the Department of Defense (DoD), such as Selected Acquisition Reports (SARs) submitted to the Congress or other publicly articulated plans. When such information was not available (for example, for programs far into the future), CBO based its projections of procurement schedules and costs on the estimated retirement ages and costs of the aircraft being replaced. Some of those estimates are based on the costs of aircraft procured by other military services or on commercial aircraft costs. When a replacement aircraft is expected to have increased capability, CBO's estimates reflect the cost of that increase.

As with any 30-year budget projections, CBO's estimates are subject to several sources of uncertainty. In particular, the size and composition of the naval aviation force may change in unanticipated ways as a result of advances in technology, budgetary constraints, or changes in the national security environment. Even at the individual aircraft level, paths different from those projected by CBO could be adopted. For example, specific plans for replacing the F/A-18E/F fighters, MV-22B tiltrotors, and eventually, the F-35B/C fighters in production today

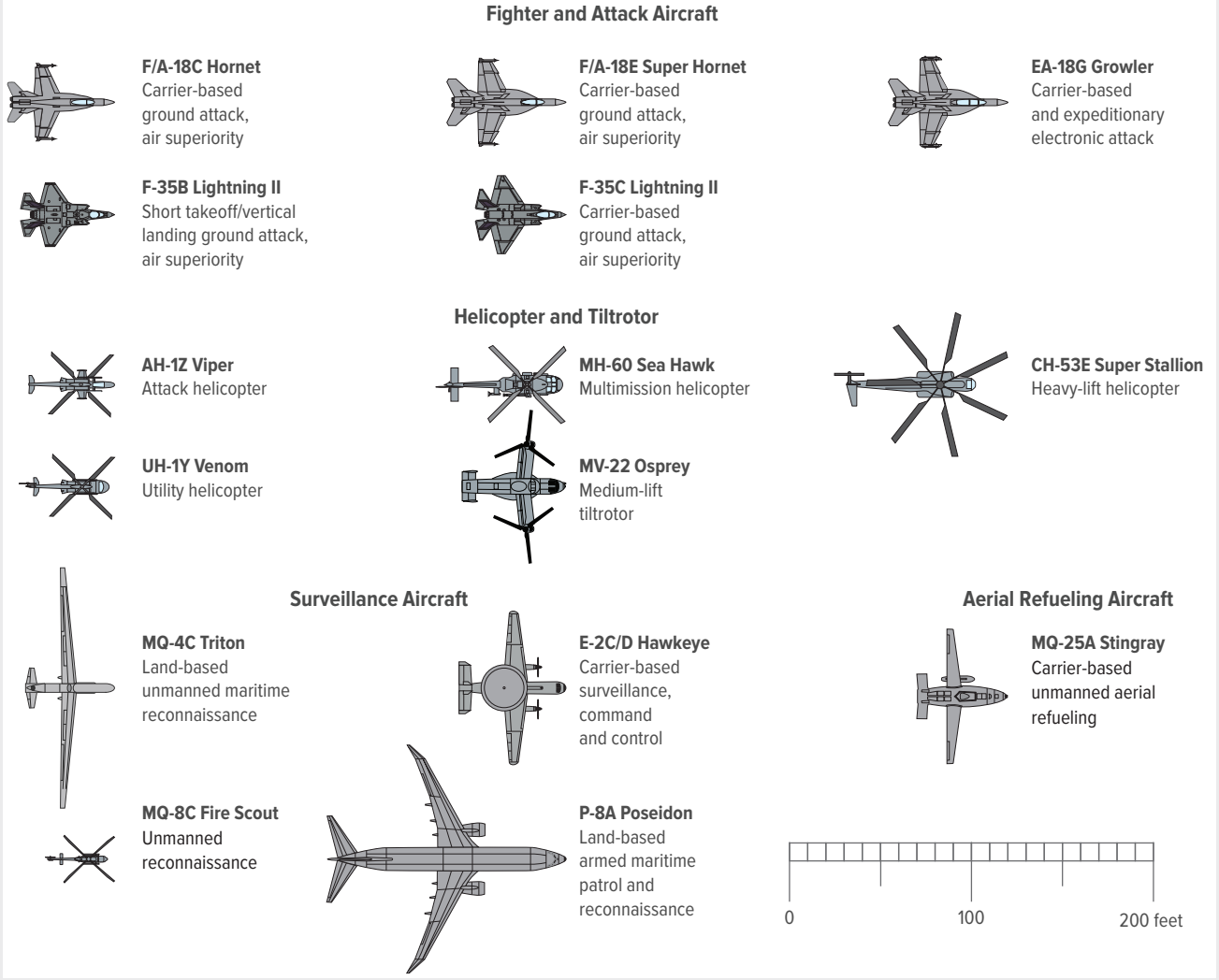
1. The data on fleet composition by age that the department provided to CBO did not separate Navy aircraft from Marine Corps aircraft; thus, aircraft types operated by both services are combined in this report.

2. CBO undertook similar analyses of Army and Air Force aircraft. See Congressional Budget Office, *The Cost of Replacing Today's Army Aviation Fleet* (May 2019), www.cbo.gov/publication/55180, and *The Cost of Replacing Today's Air Force Fleet* (December 2018), www.cbo.gov/publication/54657. CBO is also preparing another report that synthesizes the results presented here and in the earlier reports. See Congressional Budget Office, *The Cost of Replacing the Department of Defense's Current Aviation Fleet* (forthcoming).

3. Throughout this report, CBO uses the terms "purchase" and "buy" to refer to authorization by the Congress to acquire aircraft. To allow comparisons with CBO's two earlier reports on aviation costs (see footnote 2), all costs in this report are expressed in 2018 dollars.

Box 1.

Selected Aircraft in the Department of the Navy's Aviation Fleet



have not yet been developed. Policymakers could decide to replace those aircraft with more or less expensive options than CBO assumed or to not replace them at all.

Although CBO's projections address changes in the Department of the Navy's aviation fleet through 2050, the agency formed no judgment about whether the aircraft procurements in its analysis are necessary or appropriate. Nevertheless, cost projections of long-range procurement plans are useful because they can assist the Congress, the Department of Defense, and the Department of the Navy in setting budgets for procuring aircraft. They can also help decisionmakers identify important future issues—when many programs might need procurement appropriations at the same time, for example, or when to extend the service life of certain aircraft—and give them adequate time to address those issues.[4]

The Composition of Today's Navy and Marine Corps Aircraft Fleet

The Navy and Marine Corps operate a fleet of more than 4,000 aircraft of widely varying sizes and capabilities (see Box 1). According to data that the Department of the

4. See the testimony of Eric J. Labs, Senior Analyst for Naval Forces and Weapons, Congressional Budget Office, before the Subcommittee on Oversight and Investigations of the House Committee on Armed Services, *The Value of 30-Year Defense Procurement Plans for Congressional Oversight and Decisionmaking* (June 1, 2011), www.cbo.gov/publication/41497.

Navy provided to CBO, the department's aviation fleet consisted of the following aircraft as of June 30, 2018:

- **1,381 fixed-wing fighter/attack aircraft**, including 471 F/A-18A-D Hornets, 545 F/A-18E/F Super Hornets, 85 F-35B/C Lightning IIs, and 152 EA-18G Growlers (electronic attack);
- **1,347 helicopters and tiltrotor aircraft**, including 94 AH-1Z Vipers (attack helicopters), 142 CH-53E Super Stallions (heavy-lift helicopters), 529 MH-60R/S Sea Hawks (multimission helicopters), 288 MV-22B Ospreys (medium-lift tiltrotors), and 149 UH-1Y Venoms (light-lift and light-attack helicopters);
- **338 surveillance and communication aircraft**, including 72 E-2C/D Hawkeyes, 77 P-8A Poseidons, and 4 MQ-4C Tritons;
- **207 fixed-wing transport and aerial refueling aircraft**; and
- **753 trainer and adversary aircraft**, including both fixed-wing aircraft and helicopters.[5]

The ages of Navy and Marine Corps aircraft vary widely (see Table A-1 on page 14). Many are fairly new, with almost half having been acquired or remanufactured within the past 10 years (see the upper panel in Figure 1). Aircraft in the fixed-wing transport and aerial refueling category and the trainer and adversary category are, on average, the oldest in the fleet. (Adversary aircraft play the role of enemy aircraft in training exercises.) Many of the fighter/attack aircraft and helicopters have been recently replaced or are expected to be replaced over the next several years and will, therefore, not need to be replaced again until at least the latter part of CBO's 30-year projection period.

The age distribution of the fleet can also be measured in terms of what it would cost to replace all of the aircraft in each age cohort. To do so, CBO assigned each type of aircraft in the current fleet an estimated average unit cost for its future replacement and then distributed those costs by age. The resulting cost distribution was very similar to the age distribution measured by number of aircraft (see the lower panel in Figure 1). For example, the 21 percent of aircraft that are in the cohorts for ages 10 to 14 and ages 15 to 19 accounted for 18 percent of the estimated replacement value. The exceptions are the cohorts for ages 20 to 24 and ages 25 to 29, which together account for 19 percent of the fleet size but 26 percent of replacement costs.

Projecting Annual Aircraft Procurement Budgets

The Department of the Navy's annual budget for procuring aircraft averaged about $9 billion in the 2000s and about $14 billion in the 2010s (see Figure 2). Aircraft procurement represented about 25 percent of the department's total procurement budget over the 2000–2019 period, or 7 percent of the department's overall budget.[6]

Projected Annual Procurement Costs: 2020 Through 2050

CBO projects that the costs of replacing aircraft in the current fleet would average about $12 billion from 2020 to 2050. However, purchases over that period would go through several different phases and experience year-to-year variations similar to those observed in the 2000s and 2010s. Through 2030, procurement costs would average about $11 billion per year. From 2030 to 2032, annual costs would drop to about $7 billion. Most of that decrease would be the result of completing planned purchases of F-35B and F-35C fighters and CH-53K helicopters. The end of the 2020s roughly corresponds to the end of a 30-year cycle during which the Navy and Marine Corps have replaced nearly their entire aircraft fleet.

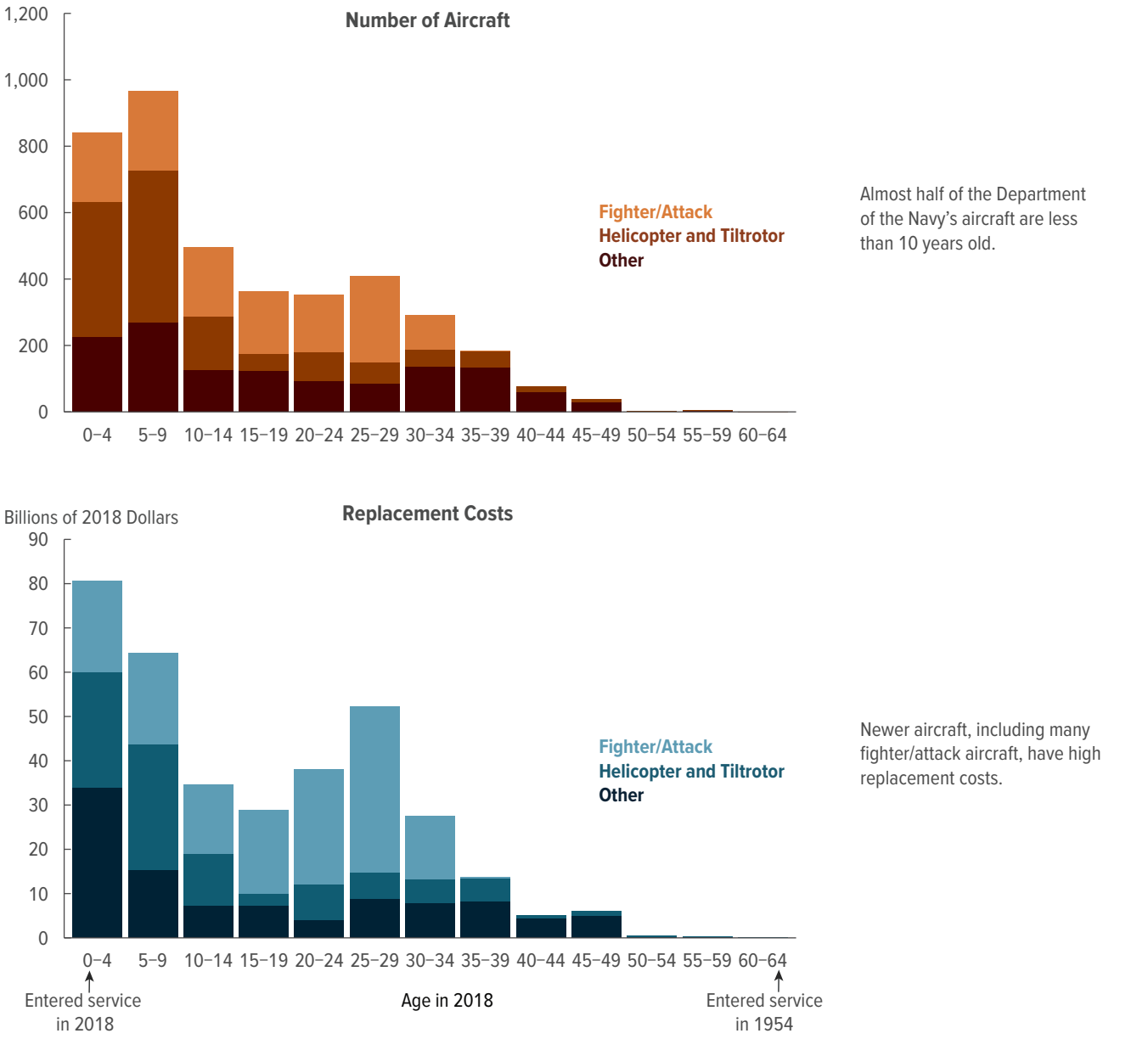
Costs would rapidly rebound after the next cycle began, reaching a high of $17 billion by 2038 and averaging about $16 billion from 2038 through 2042. Costs would

5. These are the most recent and complete data provided to CBO. See Table A-2 on page 16 for a description of each type of aircraft. For more details on the features and organization of the naval aviation force structure, see Congressional Budget Office, *The U.S. Military's Force Structure: A Primer* (July 2016), Chapter 3, www.cbo.gov/publication/51535. "Lift" refers to the transport of personnel and cargo.

6. Another large component of the Department of the Navy's procurement budget is the cost of procuring ships. See Congressional Budget Office, *An Analysis of the Navy's Fiscal Year 2020 Shipbuilding Plan* (October 2019), www.cbo.gov/publication/55685. In addition, operating costs for aircraft are typically about twice as large as procurement costs. See Congressional Budget Office, *Operating Costs and Aging of Air Force Aircraft* (January 2019), www.cbo.gov/publication/54926.

Figure 1.

Ages and Replacement Costs of the Department of the Navy's Aviation Fleet, 2018



Source: Congressional Budget Office, using data from the Department of the Navy.

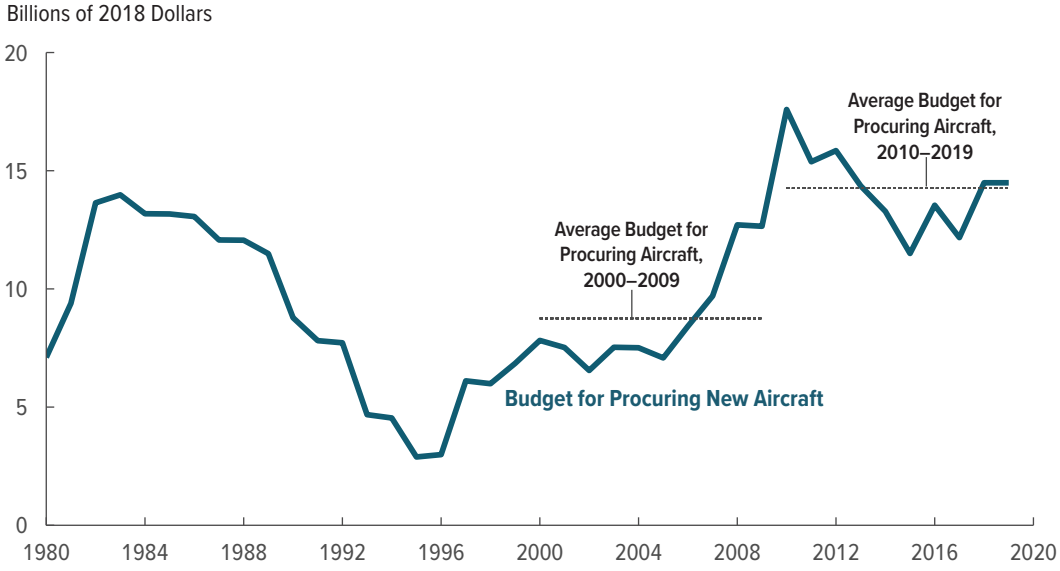
Age is measured in years since the aircraft entered the fleet. As depicted in this figure, aircraft that entered the fleet in 2018 would be age zero; aircraft that entered the fleet in 1954 would be age 64.

fall somewhat after 2042 and average about $13 billion per year through 2050 (see Figure 3).

Those annual projected costs are the sum of estimates for each individual aircraft, and they depend on the aircraft's purchase date and expected service life. (Service life is determined by factors such as the design of the aircraft, how it is used—for example, the number of flight hours and the number of carrier catapults and landings—and the environment in which it is used.) Most of the costs

Figure 2.

The Department of the Navy's Budgets for Procuring New Aircraft, 1980 to 2019



The Department of the Navy's budgets for procuring aircraft were about 60 percent greater from 2010 through 2019 than they were from 2000 through 2009.

Source: Congressional Budget Office, using data from the Department of the Navy.

through 2030 are for aircraft, such as the CH-53K, F-35B and F-35C, and MV-22B, that are being purchased to replace aircraft mostly purchased in the first half of the 1990s or earlier. After 2030, the aircraft purchased in the 2000s and 2010s would start to be retired, including the E-2D, F/A-18 E/F, and MV-22B.

The Most Costly Categories of Aircraft

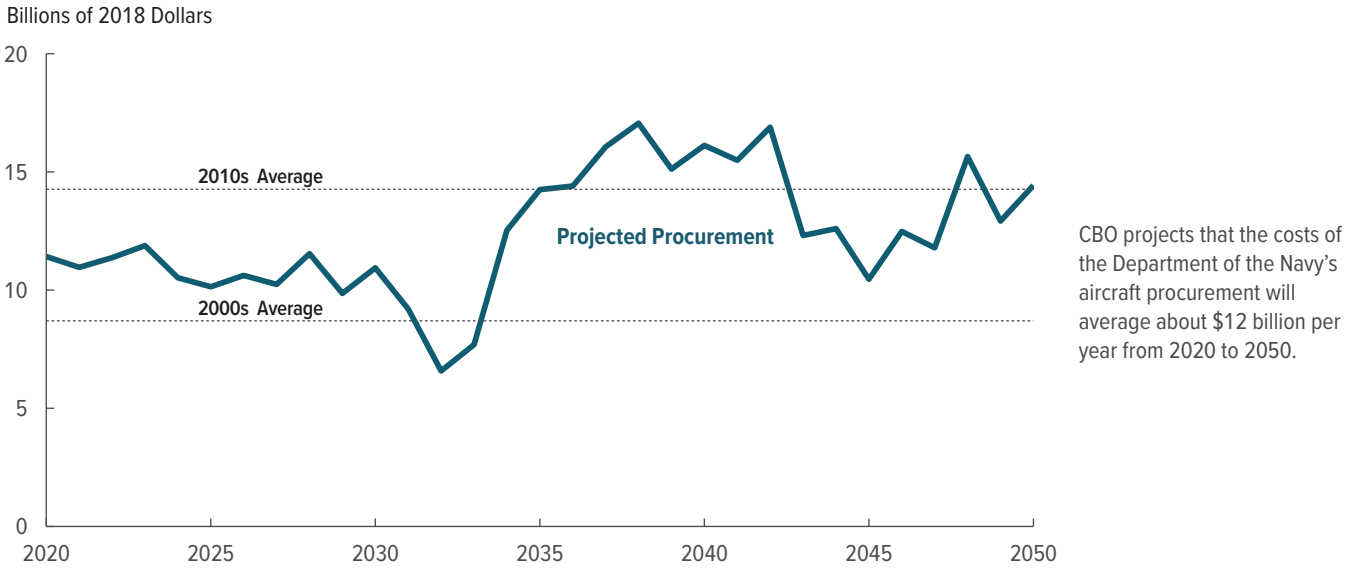
Although the Navy and Marine Corps operate about 60 models of aircraft, a small number of high-performance or otherwise technologically advanced aircraft account for a preponderance of the cost of new aircraft in CBO's projections. The two most costly categories are fighter/attack aircraft and the Marine Corps' combat rotorcraft (helicopters and tiltrotors), which together make up more than 80 percent of the costs that CBO projects for 2020 through 2050. Just the top five most expensive systems (which are in the same categories) account for more than 60 percent of total projected aircraft procurement costs (see Figure 4).

Naval Fighter/Attack Aircraft. Fighter/attack aircraft make up the most expensive category, accounting for roughly half—about $190 billion—of projected procurement costs from 2020 through 2050. The Department of the Navy is in the process of replacing more than half of its fighter/attack aircraft (the F/A-18A-D Hornets and AV-8B Harriers) with new F-35B/Cs. As of June 2018, the Navy and Marine Corps had received 58 F-35Bs and 27 F-35Cs, and 471 Hornets and 106 Harriers remained in service. According to the F-35 SAR published in December 2018, 489 F-35B/Cs would be purchased from 2020 through 2031 to replace most of those aircraft, at a cost of $59 billion (see Figure 5 on page 8). Under the assumption that F-35B/Cs would have a 30-year service life, an additional $36 billion would be incurred in the final decade of CBO's projection period when they would need to begin being replaced. Because it is unlikely that the Navy and Marine Corps would simultaneously develop two entirely new aircraft, CBO assumed that replacements for the F-35B and F-35C would be substantial upgrades akin to the upgrade from the Hornet to the Super Hornet. Procurement of replacements for the F-35B/C would continue after 2050.

Another group of about 500 fighter/attack aircraft—the F/A-18E/F Super Hornets—are expected to reach the end of their service life beginning in the early to mid-2030s. According to CBO's projections, the Navy would develop a new aircraft—currently called the FA-XX—to replace its Super Hornets. Production of that aircraft would begin in 2032 and cost $67 billion for the first 448 aircraft purchased through 2050. That cost represents an aircraft with substantial improvements

Figure 3.

Projected Costs for the Department of the Navy's Procurement of New Aircraft, 2020 to 2050



Source: Congressional Budget Office.

over the F-35C. Alternatively, the Navy could purchase F-35Cs as Super Hornets retired. Purchasing an additional 448 F-35Cs would cost about $50 billion. (The Navy would also avoid the substantial costs associated with research, development, test, and evaluation if it extended F-35C purchases rather than designing a new aircraft.)[7]

CBO also projects that production of a replacement for the electronic attack EA-18G would begin in the 2030s. However, the department will have a fleet of only 160 EA-18Gs, so the impact of their replacement on procurement budgets—about $22 billion—would not be as large as that associated with the F-35B/Cs or F/A-18E/Fs. That estimate does not include the potentially substantial cost to field new jammer pods or upgrade existing ones that might be carried by a future electronic-attack aircraft. For example, the Navy currently estimates that 128 Next Generation Jammer pods that it plans to buy for the EA-18G will cost about $4 billion.

Marine Corps Combat Rotorcraft. Today's fleet of Marine Corps combat rotorcraft consists of four types of aircraft. As of June 2018, those included 288 MV-22B tiltrotors (for medium lift), 149 UH-1Y utility helicopters (for light lift and light-attack missions), 161 AH-1W/Z helicopters (for attack and escort missions), and 142 CH-53E helicopters (for heavy lift). The MV-22Bs, UH-1Ys, and AH-1Zs are mostly new and are not scheduled to be replaced until the 2030s and 2040s.[8] However, the Marine Corps is just beginning to replace its CH-53Es with the new CH-53K. CBO projects that purchases to replace Marine Corps rotorcraft when they reach the end of their service life would total about $120 billion through 2050.

About a third of the costs for Marine Corps combat rotorcraft—approximately $43 billion—would be for medium lift, CBO projects. That total includes purchases of a few more MV-22Bs in the first half of the 2020s to complete production of that aircraft, followed shortly thereafter by production of new aircraft to begin replacing the oldest MV-22Bs (see Figure 6 on page 9).[9] Production of the MV-22B has spanned an unusually long period. The first MV-22Bs were procured in 1997

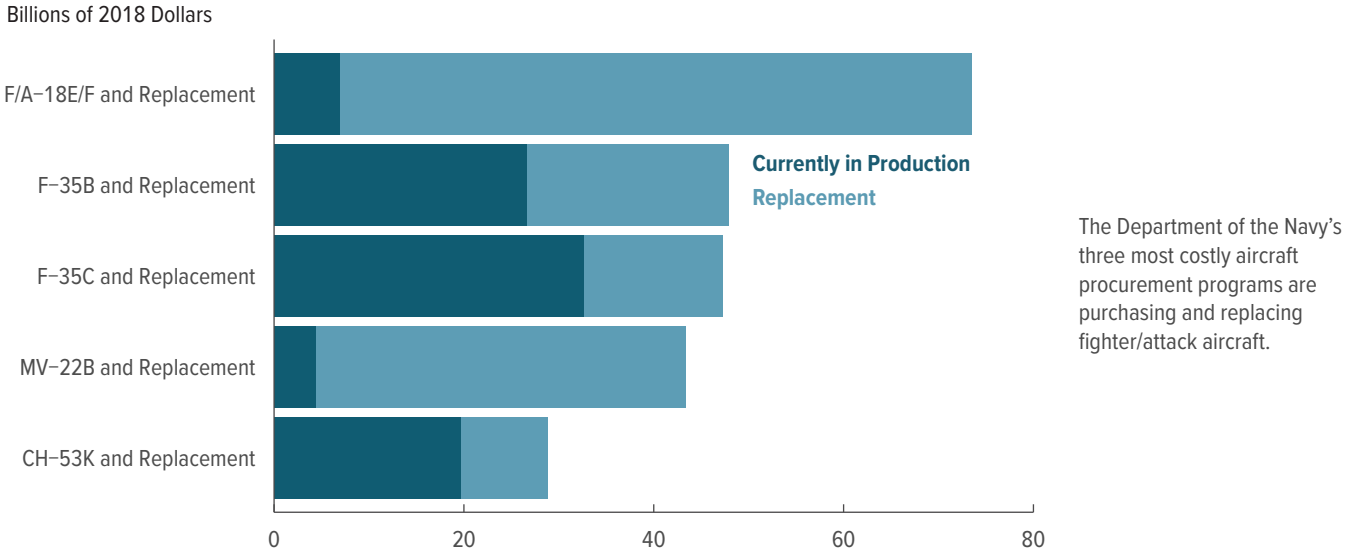
7. CBO's analysis of acquisition costs excludes the cost of developing new systems.

8. At the time of this report's publication, the last of the older AH-1W helicopters were slated to retire by 2020.

9. The Navy will use some modified MV-22Bs to resupply its aircraft carriers.

Figure 4.

The Department of the Navy's Five Aviation Programs With the Highest Projected Procurement Costs, 2020 to 2050



Source: Congressional Budget Office.

and will be about 25 years old when production ends. Because of the short time between the end of MV-22B production and the need for a replacement, CBO assumed that the replacement would be similar to the MV-22B (perhaps an upgraded version of the same basic aircraft) and have a similar unit cost. Alternatively, the Marine Corps could opt for an all new aircraft with greater improvements in capability. A larger version of the Future Long-Range Assault Aircraft (FLRAA) that is part of the Army's Future Vertical Lift program would be a possibility but might come at a higher cost.

In contrast with the relatively new MV-22B, UH-1Y, and AH-1Z aircraft, the Marine Corps is just beginning to replace its CH-53E heavy-lift helicopters with significantly more capable CH-53Ks. Procurement of the CH-53K is slated to run through 2028 and total 194 aircraft.

CBO's projections of the costs to replace the AH-1Z, which reflect the assumption that those helicopters would have a 25-year service life, include purchases of aircraft to replace them starting in about 2030 and continuing through 2043, a time frame that roughly matches the production time span of the aircraft being replaced. For the AH-1Z, the Marine Corps has indicated interest in a variant of the Army's FLRAA because such an aircraft will have a much higher speed than conventional helicopters, allowing it to operate more effectively with MV-22Bs. Accordingly, CBO based its projection of the replacement costs for AH-1Zs—about $8 billion—on its estimate of the cost of the Army's FLRAA.[10]

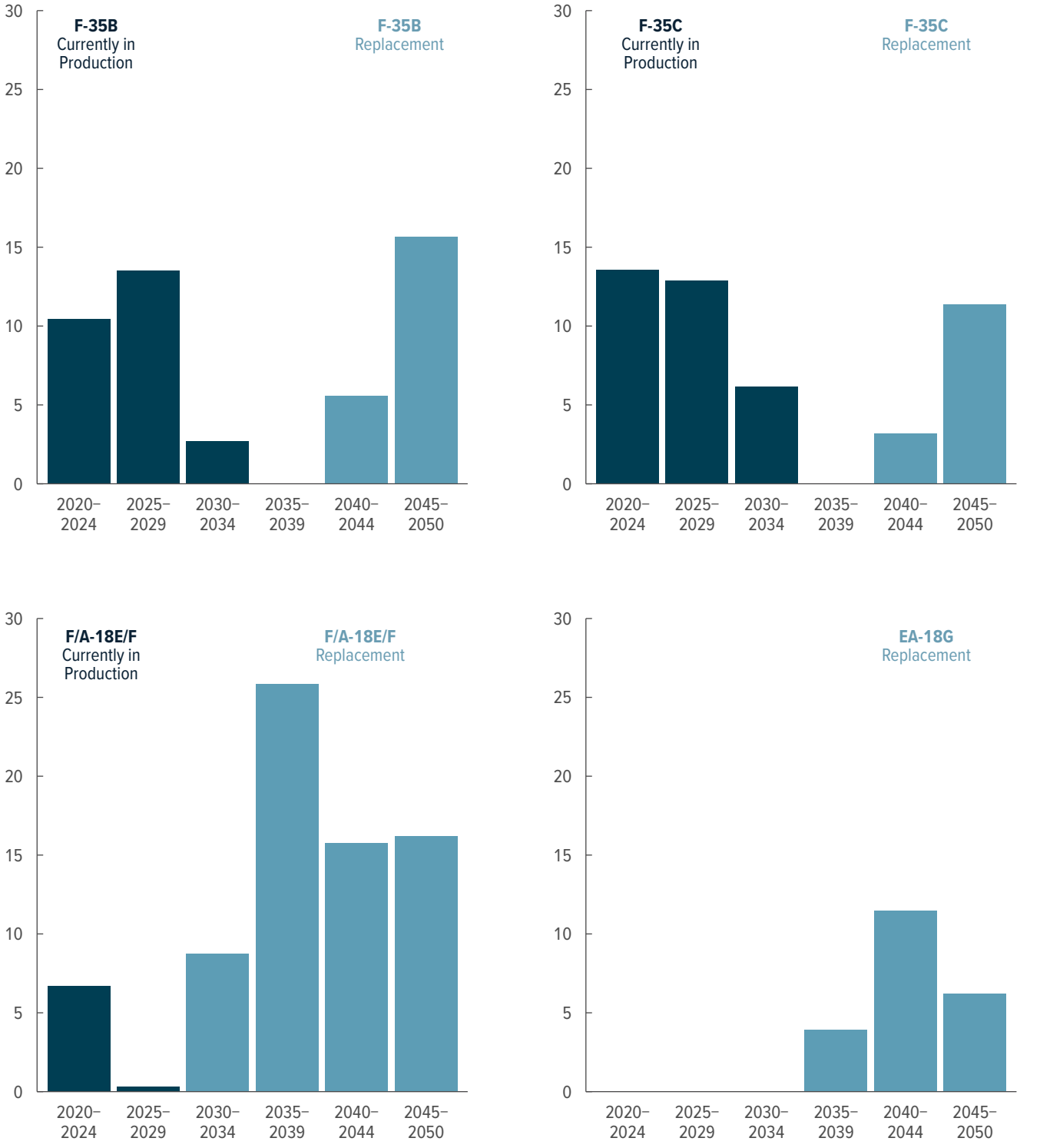
According to the December 2018 SAR, procurement costs for the CH-53K from 2020 to 2028 would total $19 billion. Based on a 25-year service life, a replacement would be needed in the mid-2040s. CBO's projection includes $10 billion from 2042 through 2050 for the first 85 aircraft to replace the CH-53K. That cost is based on the assumption that the new aircraft would be similar to the one it replaced. Costs would be higher—probably substantially higher—if the Marine Corps opted for a new heavy-lift aircraft with the speed of the MV-22B or the FLRAA-based replacements for the AH-1Z and UH-1Y.

10. The Army plans to replace its Black Hawk helicopters with FLRAAs. FLRAAs would be capable of transporting light forces and equipment farther and faster than the Black Hawk. See Congressional Budget Office, *The Cost of Replacing Today's Army Aviation Fleet* (May 2019), www.cbo.gov/publication/55180.

Figure 5.

Projected Costs for the Department of the Navy's Procurement of Selected Fighter/Attack Aircraft, 2020 to 2050

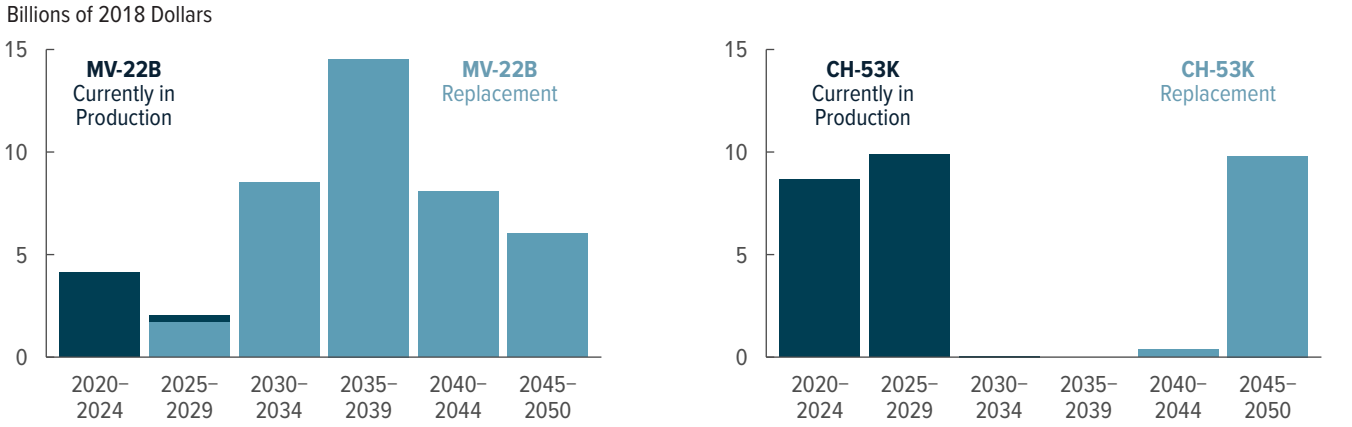
Billions of 2018 Dollars



Source: Congressional Budget Office.

Figure 6.

Projected Costs for the Department of the Navy's Procurement of Selected Helicopters and Tiltrotor Aircraft, 2020 to 2050



Source: Congressional Budget Office.

Naval Surveillance, Reconnaissance, and Aerial Refueling Aircraft. Although some surveillance aircraft are expensive, there are fewer such aircraft than in the fighter/attack category; consequently, the projected procurement total is smaller. The Navy is just finishing replacing the E-2C with the E-2D surveillance and communications aircraft, but the E-2Ds will need to be replaced starting in 2037 (see Figure 7).

According to CBO's projections, the Navy would buy 69 MQ-25A Stingray unmanned aerial refueling and reconnaissance aircraft in the 2020s for about $8 billion.[11] The new MQ-25A will not replace any existing aircraft but will relieve Super Hornets from having to fly aerial refueling missions. There is more uncertainty associated with those purchases than with others because an unmanned aerial refueling aircraft is a new concept. The MQ-25A is also expected to fill a surveillance role.

The Navy is just finishing purchasing the P-8A, a multimission aircraft, to replace the aging P-3, and it is continuing purchases of the MQ-4C, an unmanned maritime surveillance aircraft. CBO assumed a 50-year service life for the P-8A that would put replacement of that aircraft just outside the window of the agency's analysis. The airframe is that of a commercial 737, which should last more than 50 years at the rate that the Navy typically flies. However, it is unknown if the 737 will still be in commercial service 50 years from now with readily available maintenance and parts. Also, the electronics and weapon systems inside the aircraft could become obsolete before the airframe needed to be retired. So the P-8A might need to be replaced or upgraded before 2050. Although CBO did not include the cost of replacing the P-8A in its totals through 2050, the agency estimates that cost at about $35 billion, which would put the P-8A in the top five most expensive systems, if the aircraft needed to be replaced before 2050. CBO assumed MQ-4Cs would be replaced with a similar aircraft beginning in the late 2030s.

Naval Training and Adversary Aircraft. Although no single training or adversary aircraft is as expensive as the aircraft discussed so far, in total, such aircraft would cost about $15 billion between 2020 and 2050, CBO projects. Many training aircraft will need to be replaced from 2020 to 2050, including the T-6 Texan II, T-44 Pegasus, T-45 Goshawk, and TH-57 Sea Ranger.

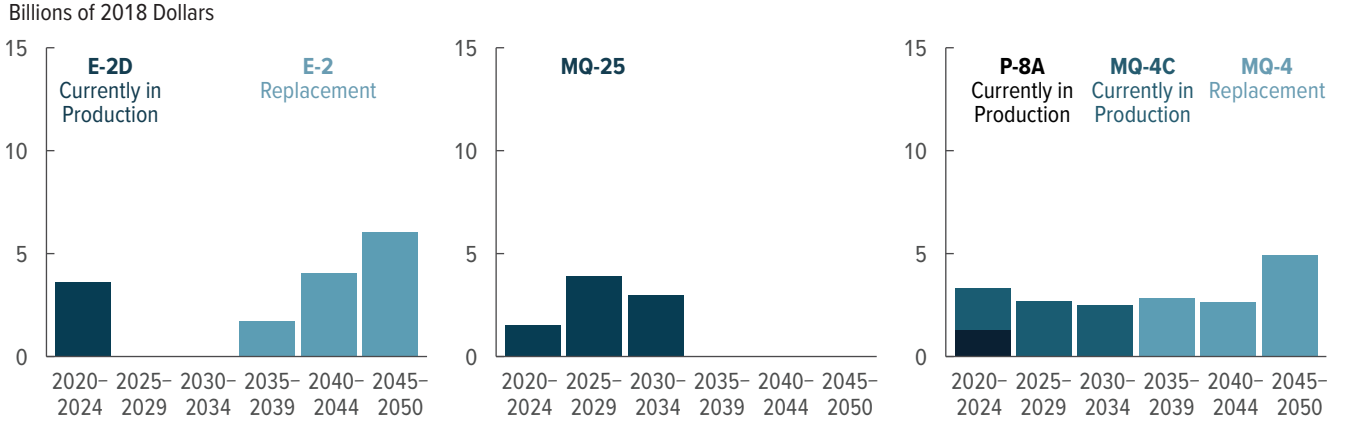
How CBO Made Its Projections

The projections described above are based on the overarching assumption that the size and composition—that is, the number of aircraft and distribution of types—of the Department of the Navy's aviation fleet would remain

11. CBO accounts for 75 MQ-25s in its projection of fleet size but includes only the 69 aircraft to be purchased with acquisition appropriations in its cost projections. The cost of six MQ-25s funded through appropriations for research, development, test, and evaluation are not considered in this report.

Figure 7.

Projected Costs for the Department of the Navy's Procurement of Selected Reconnaissance and Aerial Refueling Aircraft, 2020 to 2050



Source: Congressional Budget Office.

unchanged relative to current plans. CBO used two complementary approaches to project changes in the department's fleet and the costs of aircraft procurement associated with those changes. In the first approach, CBO simply incorporated in its projections procurement plans that have already been established by the Navy and Marine Corps. That approach primarily applied to aircraft that are in production or will enter production within the next few years. In the second approach, which CBO applied to aircraft lacking detailed replacement plans, the agency estimated when those aircraft would reach the end of their service life and incorporated their replacements in its projections accordingly.

In CBO's first approach, SARs that are prepared by the services and issued by DoD served as the primary source of established plans. CBO's projection incorporated SARs for seven types of aircraft—the F-35B/C, CH-53K, MV-22B, E-2D, KC-130J, MQ-4C, and MQ-25A. Those plans include purchases as far into the future as 2034. CBO's projections incorporate both the procurement schedules and costs contained in the SARs for those aircraft.

In its second approach, CBO used the Department of the Navy's age data for each aircraft in the fleet to estimate the year in which it would need to be replaced. CBO's estimates of service life were based on the planned or observed service life of similar naval aircraft and ranged from 25 years for helicopters to 50 years for long-range patrol aircraft (see Table A-3 on page 18).

If new aircraft were expected to be similar to the aircraft being replaced, CBO assumed that their costs would also be similar (after adjusting for inflation). For example, discussions with Marine Corps officials indicated that the replacement for the MV-22B is likely to be of similar design and capabilities. That, combined with the fact that purchases of replacements for old MV-22Bs would begin just a few years after the last MV-22B was purchased, led CBO to estimate a similar cost. By contrast, for aircraft like the F/A-18E/F, CBO estimated that its replacement would be more costly. CBO based that estimate on discussions with Navy officials and other aviation experts who indicated that a new fighter in the 2030s would probably be more capable and, therefore, more costly than the F/A-18E/F, which was designed in the 1990s.

Both of CBO's approaches are illustrated by purchases of F-35B/Cs (the first approach) and their eventual replacements (the second approach). Through fiscal year 2018, 167 of a planned 693 F-35B/Cs had been purchased for the Navy and Marine Corps (85 of which had been delivered by June 30, 2018). CBO used the F-35 SAR (published in December 2018) as its source of purchase schedules and costs for the remaining 526 aircraft. CBO tracked the ages of the F-35s and projected that replacements would be needed starting in the early 2040s if the aircraft achieved a 30-year service life typical of fighter aircraft. CBO's projections include the purchase of an F-35B/C replacement for every F-35B/C that reaches its retirement age. Because new fighters tend to include

more advanced capabilities than their predecessors, average costs tend to be higher. For the F-35B/C replacements, CBO estimated an average cost that would be about 25 percent higher than that for the F-35B/C.[12]

However, decisions about capabilities—and, by extension, costs—of many future aircraft have not yet been made. The department may decide to buy a less expensive aircraft, fewer aircraft, or no replacements at all. Because it is difficult to predict the characteristics of aircraft that will not be built until the 2030s or 2040s, cost estimates for such aircraft contribute to the uncertainty of long-term projections.

Uncertainty

Projections out to 2050 are subject to great uncertainty, primarily because of uncertainty surrounding the future national security environment and the Department of the Navy's future budgets. An aircraft's retirement may be accelerated or postponed for budgetary reasons or if advances in technology render it ineffective earlier than is currently anticipated. The Navy's or Marine Corps' force structure could change, which would change the number of aircraft needed in the future. For example, the number or size of aircraft carriers might be different in the future, which could change the number or characteristics of carrier aircraft that would be needed. The advent of unmanned aircraft, including carrier aircraft, could also change the number and types of aircraft in a future fleet in unanticipated ways.

Two examples of uncertainty involve CBO's treatment of replacements for the MV-22B and the F/A-18E/F. In the former case, CBO's projections call for a replacement similar to the MV-22B because discussions with Marine Corps officials indicated that the replacement for that aircraft is likely to have similar capabilities and because, under CBO's assumption of a 25-year service life, the first MV-22B replacement would be needed very soon after the final MV-22B was purchased. That introduces the possibility that the Marine Corps could simply continue buying the same aircraft. However, the Army's plans to develop several new vertical-lift aircraft over the next decade might offer improvements in performance or maintainability that could cause the Marine Corps to choose a different path.

In the case of a replacement for the F/A-18E/F, CBO's projections call for an all-new FA-XX with 2030s technologies and correspondingly higher costs. To keep pace with the aircraft operated by adversaries, new generations of fighters are usually more advanced than their predecessors, and both the Navy and the Air Force are conducting research in advanced fighter technologies. However, as with the MV-22B, the Navy would have the option to continue purchasing F-35C aircraft or a modestly improved version of the F-35C instead of an entirely new aircraft. The Navy could also opt to extend the service life of the F/A-18E/F fleet as it did with the F/A-18A-D fleet before it. [13]

12. The F-35 SAR describes purchases continuing through 2031 but does not report F-35Bs and F-35Cs separately. CBO estimated the annual split between F-35Bs and F-35Cs and the difference between their costs using data from the Department of the Navy's 2020 budget request, which specified quantities and costs for F-35Bs and F-35Cs separately through 2024.

13. The F/A-18A-D Service-Life Extension Program experienced problems, including declining aircraft availability. See Congressional Budget Office, *The Depot-Level Maintenance of DoD's Combat Aircraft: Insights for the F-35* (February 2018), www.cbo.gov/publication/53543.

Appendix: The Composition of the Department of the Navy's Aviation Fleet and CBO's Approach to Estimating Replacement Costs

The three tables in this appendix describe the Department of the Navy's current aviation fleet and the analytical methods the Congressional Budget Office used to project the costs of procuring aircraft.

Table A-1 shows details about the Department of the Navy's fleet as of June 30, 2018, including the number of aircraft by category and by type of aircraft within each category, as well as information about the age of the fleet.

Detailed descriptions of selected aircraft appear in Table A-2.

The replacement cost of the Department of the Navy's current fleet was calculated as follows: The fleet size of each type of aircraft (shown in Table A-1) was multiplied by its estimated average per-unit replacement cost (shown for selected aircraft in Table A-3).

To project the annual costs of procuring aircraft, CBO developed an annual aircraft retirement schedule based on plans published by the Department of the Navy (when available) or based on historical ages at which aircraft retire. Given that retirement schedule, CBO projected the annual procurement costs associated with replacing aircraft one-for-one when they retire, allowing the cost of aircraft to change over time because of the effects of "learning" (the gains in efficiency that accrue over the duration of an aircraft's production as workers gain familiarity with a particular aircraft model) and "scale" (the production efficiencies that are made possible when additional quantities of aircraft of the same type are built simultaneously or in close succession at a given facility). The replacement costs listed in Table A-3 are the average per-unit cost over the procurement period.

Table A-1.

Number and Age of the Department of the Navy's Aircraft as of June 30, 2018

Aircraft	Number	Age in 2018 (Years)		
		Minimum	Average	Maximum
Fighter/Attack	**1,223**	**0**	**17.6**	**36**
AV-8B	106	14	22.0	28
F-35B	58	0	3.7	6
F-35C	27	1	3.2	5
F/A-18A	61	30	32.0	33
F/A-18B	11	31	33.5	36
F/A-18C	282	19	25.6	30
F/A-18D	117	17	25.4	30
F/A-18E	289	0	9.9	21
F/A-18F	256	3	12.2	21
Other fighter/attack	16	25	28.8	30
Electronic Attack	**158**	**0**	**6.2**	**32**
EA-18G	152	0	5.3	11
EA-6B	6	30	31.1	32
Helicopter and Tiltrotor	**1,347**	**0**	**11.6**	**56**
AH-1W	67	20	27.0	40
AH-1Z	94	0	3.7	11
CH-53E	142	18	30.2	37
CH-53K	1	0	0	0
HH-60H	9	21	25.0	29
MH-53E	29	23	27.1	32
MH-60R	269	0	5.6	12
MH-60S	260	2	9.8	18
MV-22B	288	0	6.6	14
UH-1Y	149	0	4.9	11
Other helicopter and tiltrotor	39	6	37.0	56
Surveillance/Communication	**338**	**0**	**14.6**	**54**
E-2C	39	8	16.7	29
E-2D	33	0	4.0	11
E-6B	16	26	27.5	28
EP-3E	15	26	45.7	49
MQ-4C	4	0	2.0	3
MQ-8B	23	3	6.2	8
MQ-8C	19	2	2.6	3
P-3C	61	28	37.5	54
P-8A	77	0	2.9	8
RQ-21A	19	0	1.6	4
RQ-23A	10	3	3.9	5
RQ-26A	2	11	15.5	19
RQ-7B	15	1	7.9	11
Other surveillance/communication	5	13	16.9	28

Continued

Table A-1. Continued

Number and Age of the Department of the Navy's Aircraft as of June 30, 2018

Aircraft	Number	Age in 2018 (Years)		
		Minimum	Average	Maximum
Fixed-Wing Transport and Aerial Refueling	**207**	**1**	**21.1**	**57**
C-130T	20	21	24.2	26
C-2A	34	28	30.9	33
C-26D	7	24	25.7	26
C-40A	15	1	11.3	17
KC-130J	53	1	10.4	17
KC-130T	24	22	28.4	34
Other fixed-wing transport and aerial refueling	54	1	23.1	57
Trainer/Adversary	**753**	**2**	**20.1**	**61**
F-16A	10	15	24.5	26
F-16B	4	15	21.5	23
F-5F	3	8	27.8	39
F-5N	40	11	38.4	40
T-34C	16	28	37.8	41
T-38C	10	46	50.3	55
T-44C	54	38	40.0	41
T-45C	193	8	18.1	27
T-6A	43	13	14.8	15
T-6B	251	2	5.9	8
TH-57B	41	32	33.3	36
TH-57C	79	33	34.9	35
Other trainer/adversary	9	8	21.1	61
Total Fleet	**4,026**	**0**	**15.5**	**61**

Source: Congressional Budget Office, using data from the Department of the Navy.

Age is depicted in years since the aircraft entered the fleet. Aircraft that entered the fleet in 2018 are considered to be age zero; the oldest aircraft, an NU-1B Otter, entered the fleet in 1956 and was age 61 on June 30, 2018.

Table A-2.

Descriptions of Selected Naval Aircraft

Aircraft	Manufacturer	Primary Operating Platform	Primary Function	Engine	Wingspan or Rotor Diameter (Feet)	Length (Feet)	Maximum Gross Weight (Pounds)	Maximum Speed (Miles per hour)
Fighter/Attack								
AV-8B	McDonnell Douglas (now Boeing)	Amphibious ships	Ground-attack aircraft	1 Rolls-Royce turbofan	30.3	46.3	31,000	668
F-35B	Lockheed Martin	Amphibious ships	Multirole attack and fighter aircraft	1 Pratt & Whitney turbofan	35.0	51.2	60,000	1,227
F-35C	Lockheed Martin	Carrier	Multirole attack and fighter aircraft	1 Pratt & Whitney turbofan	43.0	51.6	70,000	1,227
F/A-18A/B/C/D	McDonnell Douglas (now Boeing)	Carrier	Multirole attack and fighter aircraft	2 GE turbofans	40.7	56.0	44,400	1,189
F/A-18E/F	Boeing	Carrier	Multirole attack and fighter aircraft	2 GE turbofans	44.7	60.3	66,000	1,189
Electronic Attack								
EA-18G	Boeing	Carrier	Electronic attack	2 GE turbofans	44.9	60.2	48,000	1,189
Helicopter and Tiltrotor								
AH-1Z	Bell Helicopter	Amphibious ships	Light attack gunship	2 GE turboshafts	48.0	58.3	18,500	255
CH-53K	Sikorsky	Amphibious ships	Heavy-lift cargo	3 GE turboshafts	72.0	99.0	84,700	196
MH-60R	Sikorsky	Surface combatant	Multimission	2 GE turboshafts	53.7	64.8	22,500	166
MH-60S	Sikorsky	Surface combatant	Multimission	2 GE turboshafts	53.7	64.8	23,500	177
MV-22B	Bell/Boeing	Amphibious ships	Multimission	2 Rolls-Royce turboshafts	45.8	57.3	60,500	351
UH-1Y	Bell Helicopter	Land	Transport	2 Pratt & Whitney turboshafts	48.0	58.3	18,500	135
Surveillance/Communication								
E-2D	Northrop Grumman	Carrier	Early-warning craft	2 Allison turboprops	80.6	57.8	57,500	403
E-6B	Boeing	Land	Airborne command	4 GE turbofans	148.4	150.4	342,000	607
MQ-4C	Northrop Grumman	Land	Unmanned aerial surveillance	1 Rolls-Royce turbofan	130.9	47.6	32,250	357
MQ-8C	Northrop Grumman	Surface combatant	Multimission	1 Rolls-Royce turboshaft	35.0	41.4	6,000	155
P-8A	Boeing	Land	Multimission	2 CFM turbofans	123.5	129.5	189,700	464
RQ-21A	Boeing	Land	Unmanned aerial surveillance	1 piston engine	16.0	832.0	135	104

Continued

Table A-2. Continued

Descriptions of Selected Naval Aircraft

Aircraft	Manufacturer	Primary Operating Platform	Primary Function	Engine	Wingspan or Rotor Diameter (Feet)	Length (Feet)	Maximum Gross Weight (Pounds)	Maximum Speed (Miles per hour)
Cargo and Transportation								
C-130T	Lockheed Martin	Land	Global airlift	4 Allison turboprops	132.6	97.7	155,000	374
C-40A	Boeing	Land	Transport	2 GE turbofans	112.6	110.3	171,000	615
VH-3D	Sikorsky	Land	Executive transport	2 GE turboshafts	63.0	73.0	21,500	161
VH-60N	Sikorsky	Land	Executive transport	2 GE turboshafts	53.7	64.8	17,000	185
Aerial Refueling								
KC-130J	Lockheed Martin	Land	Aerial refueling	4 Allison turboprops	132.6	97.8	164,000	391
MQ-25	Boeing	Carrier	Aerial refueling	1 Rolls-Royce turbofan	75.0	51.0	n.a.	n.a.
Trainer/Adversary								
F-16A	General Dynamics	Land	Adversary	1 Pratt & Whitney turbofan	32.8	47.7	33,000	1,345
F-16B	General Dynamics	Land	Adversary	1 Pratt & Whitney turbofan	32.8	47.7	33,000	1,345
F-5N	Northrop Grumman	Land	Adversary	2 GE turbojets	26.7	47.4	24,700	1,258
T-38C	Northrop Grumman	Land	Trainer	2 GE turbojets	25.3	46.8	12,100	812
T-44C	Beechcraft	Land	Trainer	2 Pratt & Whitney turboprops	50.2	35.5	9,650	288
T-45C	Boeing	Land	Trainer	1 Rolls-Royce turbofan	30.8	35.8	14,100	609
T-6B	Hawker Beechcraft (now Beechcraft)	Land	Trainer	1 Pratt & Whitney turboprop	33.3	33.4	6,500	310
TH-57C	Bell Helicopter	Land	Trainer	1 Allison turboshaft	35.4	41.0	3,000	138

Source: Congressional Budget Office, using data from various sources including Norman Polmar, *The Naval Institute Guide to the Ships and Aircraft of the U.S. Fleet* (2013), and *The U.S. Navy Fact File*, www.navy.mil/navydata/fact.asp.

n.a. = not available.

Table A-3.

CBO's Estimates of the Retirement Age and Per-Unit Replacement Cost of Selected Aircraft

Aircraft	Maximum Age	Average Replacement Cost (Millions of 2018 dollars)	Assumptions
Fighter/Attack			
F-35B/C	30	195[a]	Assume a more advanced aircraft. Procurement starts in 2041.
F/A-18 E/F	30	149	Assume a more advanced aircraft. Procurement starts in 2032.
EA-18G	30	135	Assume a more advanced aircraft. Procurement starts in 2030.
Helicopter and Tiltrotor			
AH-1Z	25	75	Assume an aircraft similar to the Army's FLRAA. Procurement starts in 2030.[b]
CH-53K	25	120	Assume an aircraft similar to current model. Procurement starts in 2042.
MH-60R/S	25	52[c]	Assume an aircraft similar to current model. Procurement starts in 2027.
MV-22B	25	109	Assume an aircraft similar to current model. Procurement starts in 2030.
Surveillance/Communication			
E-2D	25	206	Assume a more advanced aircraft. Procurement starts in 2035.
P-8A	50	334	Assume a more advanced aircraft. Procurement starts in 2058.

Source: Congressional Budget Office.

CBO's estimates incorporate the assumption that funding for an aircraft would be appropriated two years before the aircraft entered service. The replacement cost is the average per-unit cost for aircraft purchased through 2050.

FLRAA = Future Long-Range Assault Aircraft.

a. Cost reflects the average of B-model and C-model replacements.

b. The Army plans to replace its Black Hawk helicopters with FLRAAs. FLRAAs would be capable of transporting light forces and equipment farther and faster than the Black Hawks that the FLRAAs would replace. CBO assumes that the Marine Corps would procure a similar aircraft to replace the AH-1Z but at a higher per-unit cost to account for equipment needed for attack missions. See Congressional Budget Office, *The Cost of Replacing Today's Army Aviation Fleet* (May 2019), www.cbo.gov/publication/55180.

c. Cost reflects the average of R-model and S-model replacements.

List of Tables and Figures

Tables

Figures

About This Document

This Congressional Budget Office report was prepared at the request of the Chairman and Ranking Member of the Senate Budget Committee. In keeping with CBO's mandate to provide objective, impartial analysis, the report makes no recommendations.

R. Derek Trunkey, David Arthur, Edward G. Keating, and John Kerman prepared the report with guidance from David Mosher. Eric J. Labs fact-checked it.

David Newman and Jennifer Shand of CBO provided helpful comments, as did J.J. Gertler of the Congressional Research Service, Julianne Nelson of CNA, and officials from the Department of the Navy. (The assistance of external reviewers implies no responsibility for the final product, which rests solely with CBO.) Bernard Kempinski (formerly of CBO) and Robert Rebach created the artwork shown in Box 1.

Wendy Edelberg and Jeffrey Kling reviewed the report. Loretta Lettner was the editor, and Robert Rebach was the graphics editor and cover illustrator. An electronic version is available on CBO's website (www.cbo.gov/publication/55949).

CBO continually seeks feedback to make its work as useful as possible. Please send any comments to communications@cbo.gov.

Phillip L. Swagel
Director
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