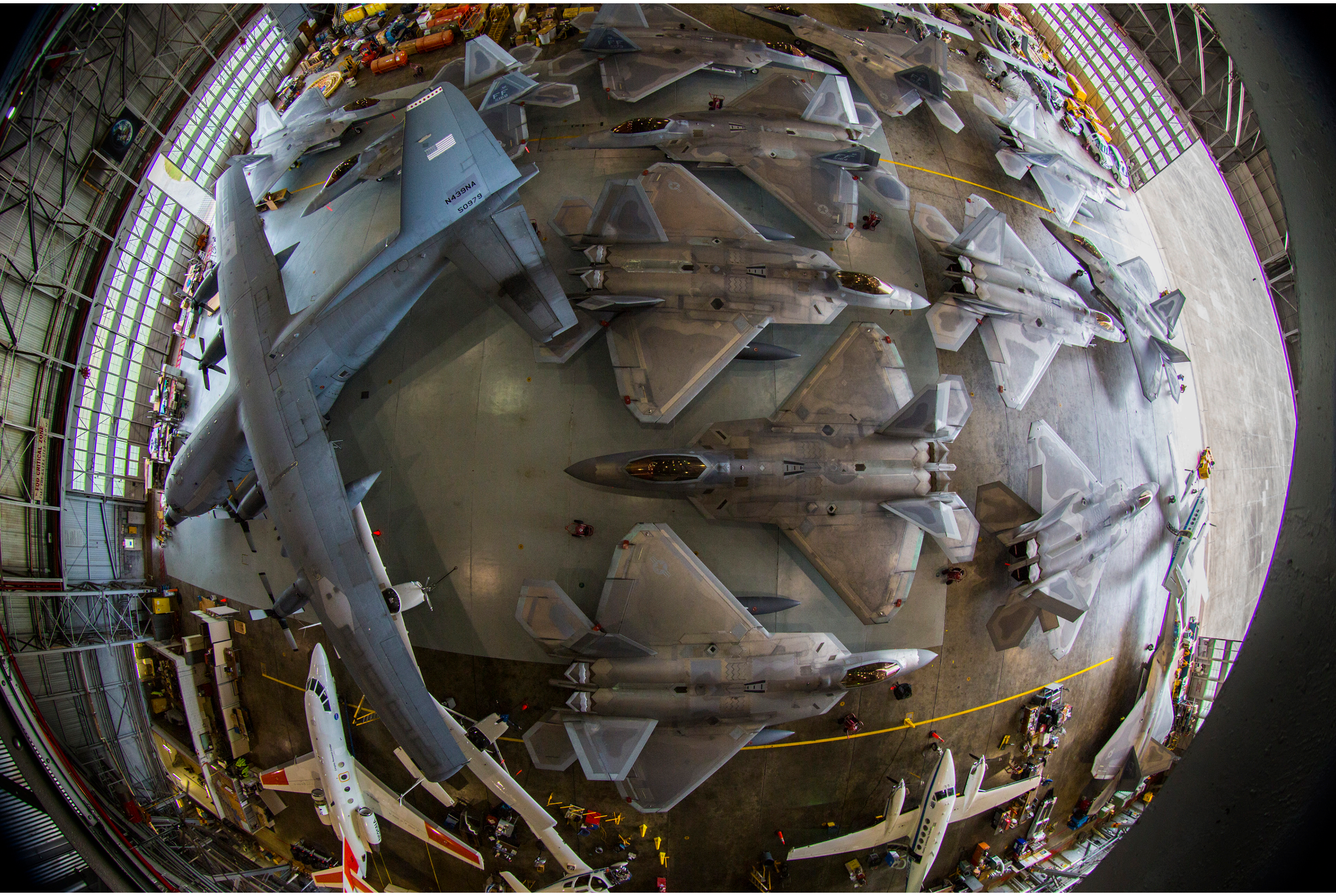
OCTOBER 2019



The Air Force of the Future

A Comparison of Alternative Forces Structures

Author
TODD HARRISON

CSIS | CENTER FOR STRATEGIC & INTERNATIONAL STUDIES

A Report of the
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Introduction

Section 1064 of the fiscal year (FY) 2018 National Defense Authorization Act (NDAA) mandated three separate studies of the Air Force's current and future force structure. The law specified that the studies consider future threats to air and space forces, traditional and alternative roles and missions for the Air Force, the role of new technology and remotely piloted aircraft (RPAs), and operation and sustainment costs, among other factors. It further mandated that each study include a force-sizing construct for the Air Force and recommended inventories by aircraft type in the 2030 timeframe. The statutory deadline for the studies was March 1, 2019, although the studies were not publicly released until after this date.[1] The three studies were conducted by the Air Force, in conjunction with the Office of Net Assessment; the MITRE Corporation, a federally-funded research and development center (FFRDC); and the Center for Strategic and Budgetary Assessments (CSBA), an independent 501(c)(3) think tank.

The requirement for three independent force structure studies began in the Senate version of the FY 2018 NDAA. The report accompanying the Senate's version of the bill notes that "the Air Force currently lacks an understandable and sufficient aircraft inventory force-sizing rationale." It goes on to state that the intended purpose of the three studies is to "provide competing visions and alternatives for a future set of choices regarding Air Force aircraft capabilities and capacities."[2] While the House version of the FY 2018 NDAA did not contain a similar provision, the conference committee elected to keep the Senate provision in the final version of the bill, which was signed into law on December 12, 2017.

The Air Force study requirement was modeled on a provision in a previous NDAA requiring a similar review of Navy force structure. In section 1067 of the FY 2016 NDAA, Congress mandated three independent studies of the Navy's future fleet. Like the more recent legislation, it required that one study be conducted by the service, one by an FFRDC, and one by an independent think tank, and both legislative provisions required an assessment of the future force structure in 2030.[3]

1. National Defense Authorization Act for Fiscal Year 2018, Title X, Subtitle F, Pub. L. 115-91, sec. 1064 (December 12, 2017), https://www.congress.gov/115/plaws/publ91/PLAW-115publ91.pdf.
2. United States Senate Committee on Armed Services, "National Defense Authorization Act for Fiscal Year 2018 Report," July 10, 2017, 236, https://www.congress.gov/115/crpt/srpt125/CRPT-115srpt125.pdf.
3. National Defense Authorization Act for Fiscal Year 2016, Title X, Subtitle F, Pub. L. 114-92, sec. 1067 (November 25, 2015), https://www.congress.gov/114/plaws/publ92/PLAW-114publ92.pdf.

Importantly, the NDAA did not mandate that the studies be conducted without resource constraints. Senate report language stated that, "the committee believes Air Force aircraft inventories should be planned and procured at levels necessary to support the fundamental tenets of our national security and national defense strategies, as opposed to allowing arbitrary budget restrictions to drive U.S. national security strategy." But neither the report language or the text of the law itself states that the studies should be conducted without regard for resource or budgetary constraints.

The challenge for the Air Force, however, is to execute the 2018 National Defense Strategy (NDS) within the resource constraints imposed by the administration and Congress. The NDS says that the Department of Defense (DoD) "must make difficult choices and prioritize what is most important to field a lethal, resilient, and rapidly adapting Joint Force."[4] In order to carry out the strategy, the Air Force must simultaneously modernize its inventory of aircraft to address future threats, maintain a sufficient force structure to meet projected operational demands, and sustain a sufficient level of readiness for current operations. Moreover, it must meet these challenges with a budget that is projected in the FY 2020 request to be essentially flat with inflation for the foreseeable future.

The purpose of this report is to compare, contrast, and critique the three studies of the Air Force's future force structure. While each study had the option of producing a classified annex with additional material, this analysis only considers the unclassified material released from the three studies. It provides an independent assessment of the current state of the Air Force, areas where the studies agree, areas where they disagree, and areas where additional research and analysis is needed.

4. James Mattis, "Summary of the 2018 National Defense Strategy of the United States of America," Department of Defense, 2018, 1, https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf.

01

Current State of The Air Force

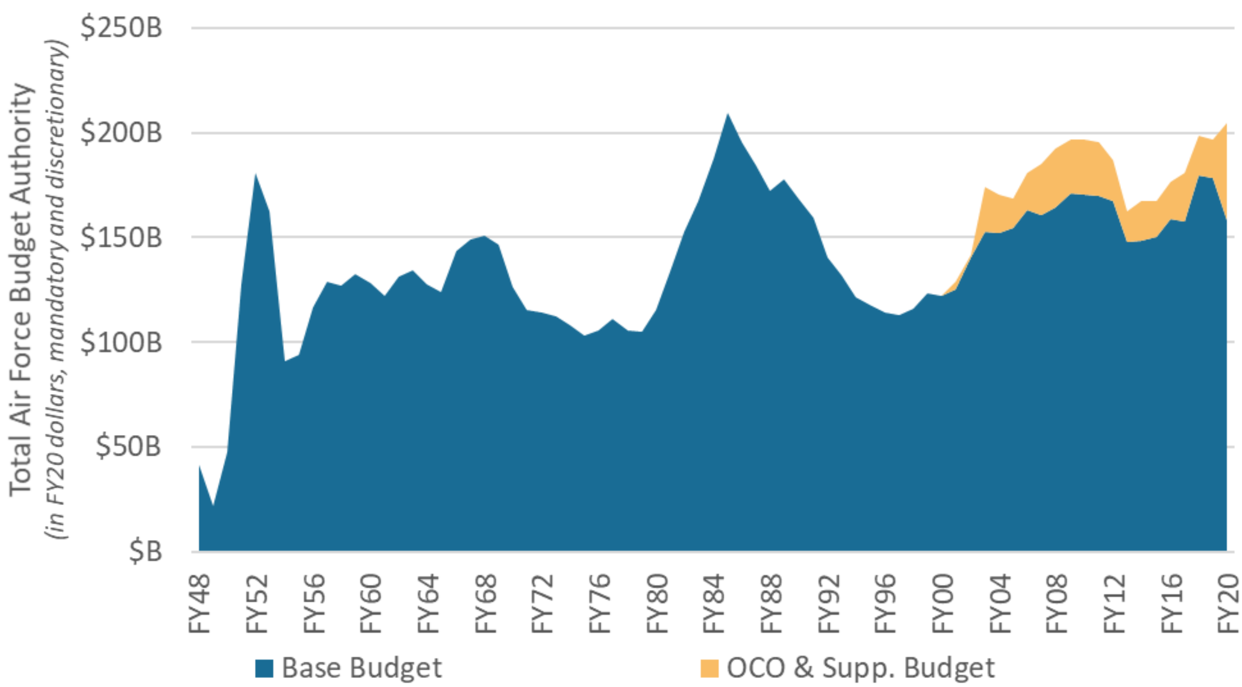
The current state of the Air Force serves as an important backdrop for this comparative analysis. The Air Force's budget has historically been cyclical, rising and falling with trends in the overall defense budget. Despite these ups and downs in the budget—and the service's FY 2020 request being near an all-time high—the size of the Air Force, as measured by the number of personnel and aircraft in the inventory, has steadily declined over time. This chapter examines trends in the overall budget, the mix of aircraft in the inventory, operating costs, aircraft utilization rates, mishap rates, and mission capable rates. Together these trends provide important context for evaluating the size, composition, affordability, and sustainability of the future force.

BUDGET AND FORCE STRUCTURE TRENDS

Like the overall DoD budget, the Air Force's budget has experienced four complete boom and bust cycles since its creation in 1947, and it may be at or near the peak of another budget cycle right now. The total Air Force budget, including classified and pass-through funding, reached a post-Cold War low in FY 1997 of $73 billion (or $113 billion in FY 2020 dollars) after more than a decade of annual reductions.[5] As shown in Figure 1, the budget began growing modestly in FY 1998, and growth accelerated after the terrorist attacks of September 11, 2001. From FY 2000 to FY 2010, the Air Force's total budget grew by 61 percent, adjusting for inflation. While some of this growth was due to operations in Iraq and Afghanistan, most of this growth (65 percent) was in the Air Force's base budget, which does not include funding for Overseas Contingency Operations (OCO). The budget declined briefly by a total of 17 percent in real terms from FY 2010 to FY 2013, but it returned to growth for FY 2014 through FY 2019. The Air Force's FY 2020 budget request would bring the total budget to a level that is higher in real terms than the peak reached at the height of the wars in Iraq and Afghanistan in FY 2010 and the second highest ever in the history of the Air Force.

5. All adjustments for inflation in this report are made using the GDP Chained Price Index (published by the Office of Management and Budget (OMB) in Historical Table 10.1) rather than the deflators used by DoD. The defense deflators count some of the growth in labor costs for military and civilian employees as inflation and therefore understate the growth in these accounts over time. Unless otherwise noted, the budget data in this report includes discretionary and mandatory funding, as well as base and Overseas Contingency Operations (OCO) funding.

Figure 1: Total Air Force Budget Authority

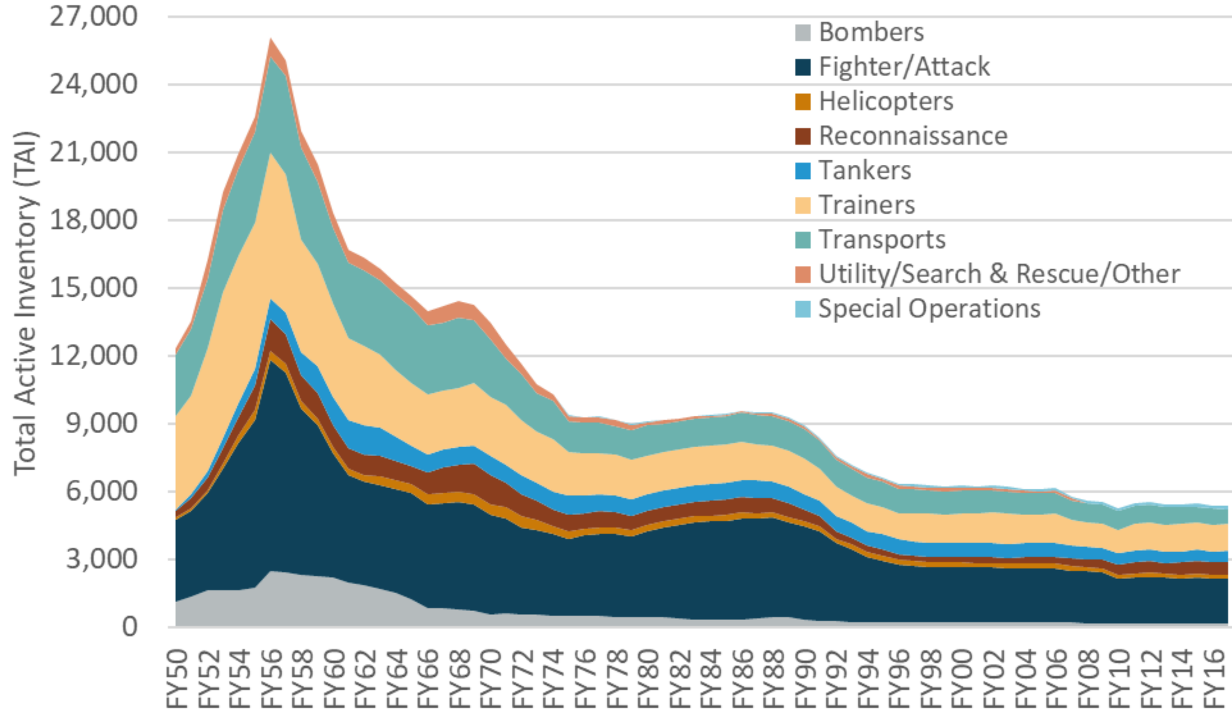


Source: Office of the Under Secretary of Defense (Comptroller), *National Defense Budget Estimates for FY 2020*, May 2019, Table 6-10.

The Air Force's force structure, however, follows a different trend. In contrast to the ups and downs in the budget, the total active inventory (TAI) of aircraft and the end strength of the Air Force have gradually declined over the past 30 years.[6] As shown in Figure 2, the number of aircraft declined by 34 percent from the most recent peak in FY 1986 through FY 1997. Over the same period, active duty end strength fell by 38 percent, and the number of civilian full-time equivalents fell by 32 percent. But as the budget began growing in the late-1990s and throughout the 2000s, both the number of personnel and aircraft continued to decline. When the Air Force's most recent budget cycle peaked in FY 2010, the aircraft inventory hit an all-time low, and active duty end-strength reached an all-time low of 311,000 in FY 2015.

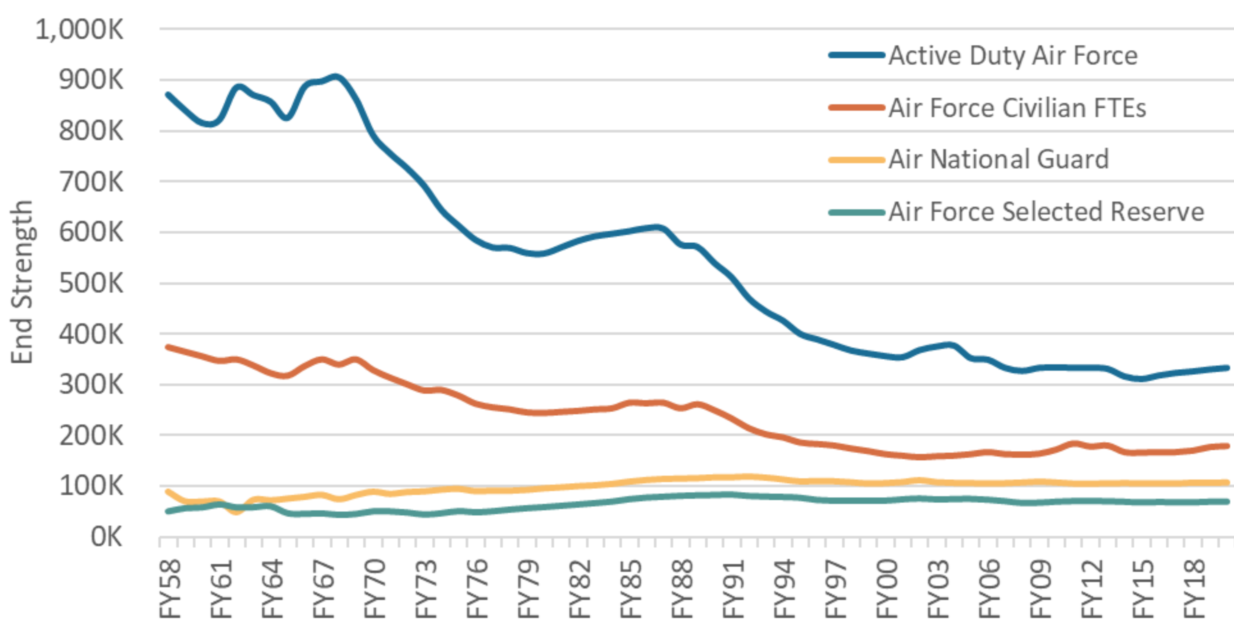
6. TAI includes aircraft assigned to operating forces for mission, training, test, and maintenance. It includes the backup aircraft inventory and attrition reserve. TAI does not include inactive aircraft that are in storage, on loan or leased outside of DoD, or otherwise not available for military use.

Figure 2: Air Force Total Aircraft Inventory



Source: James Ruehrmund Jr. and Christopher Bowie, *Arsenal of Airpower: USAF Aircraft Inventory 1950-2016* (Arlington, VA: Mitchell Institute for Aerospace Studies, February 2018). The data is updated to include the 2017 inventory and to correct for reporting errors in prior years.

Figure 3: Air Force End Strength



Sources: Office of the Under Secretary of Defense (Comptroller), *National Defense Budget Estimates for FY 2020*, May 2019, Table 7-5.

This combination of trends—a budget that is near an all-time high and a force structure that is near an all-time low—suggests that the Air Force is facing a set of budgetary and force structure challenges today that are unlike what it has encountered in the past. When the Air Force budget reached its all-time high in FY 1985 of $210 billion in FY 2020 dollars (or $99.4 billion in then-year dollars), it had an inventory of more than 9,400 aircraft (TAI) with an active duty end strength of 602,000 and 264,000 civilian full-time equivalents (FTEs). The Air Force budget request for FY 2020 is similar in size at $205 billion but only supports some 5,300 aircraft, 333,000 active duty service members, and 179,000 civilian FTEs. For roughly the same level of funding as it received at the height of the Cold War, the Air Force of today has nearly half as many aircraft and active duty service members. This is because the costs of operating, staffing, and equipping the force have become increasingly expensive over time.[7] Progressively more funding is needed to support a shrinking force, and this trend is not likely to be sustainable in the long term.

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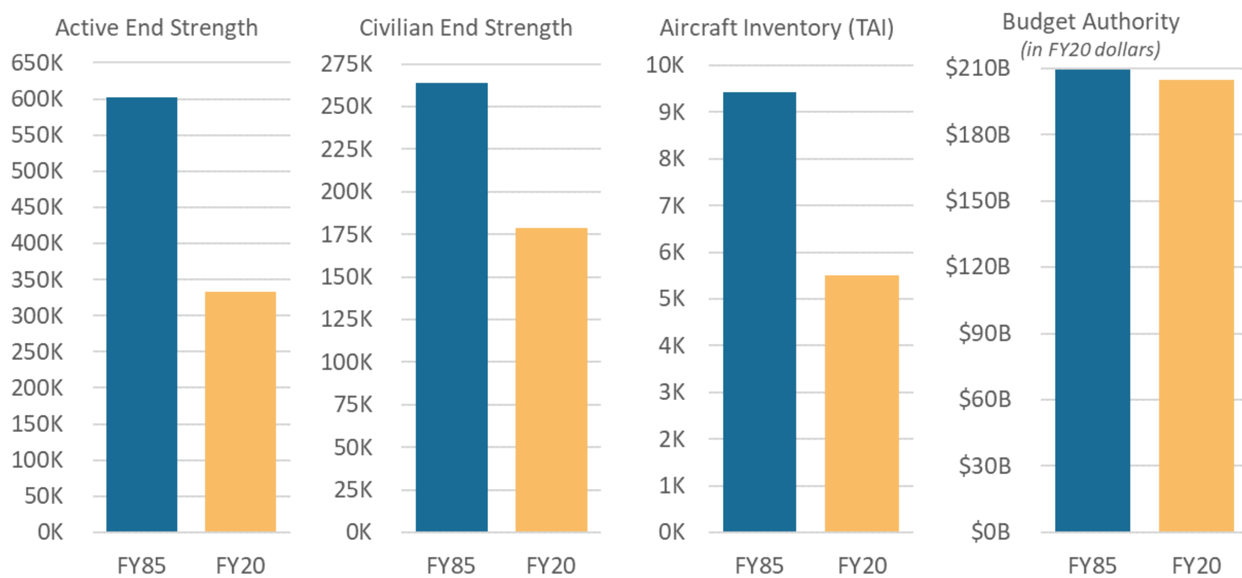
Figure 4: Comparison of the U.S. Air Force Then (FY 1985) and Now (FY 2020 Budget Request)



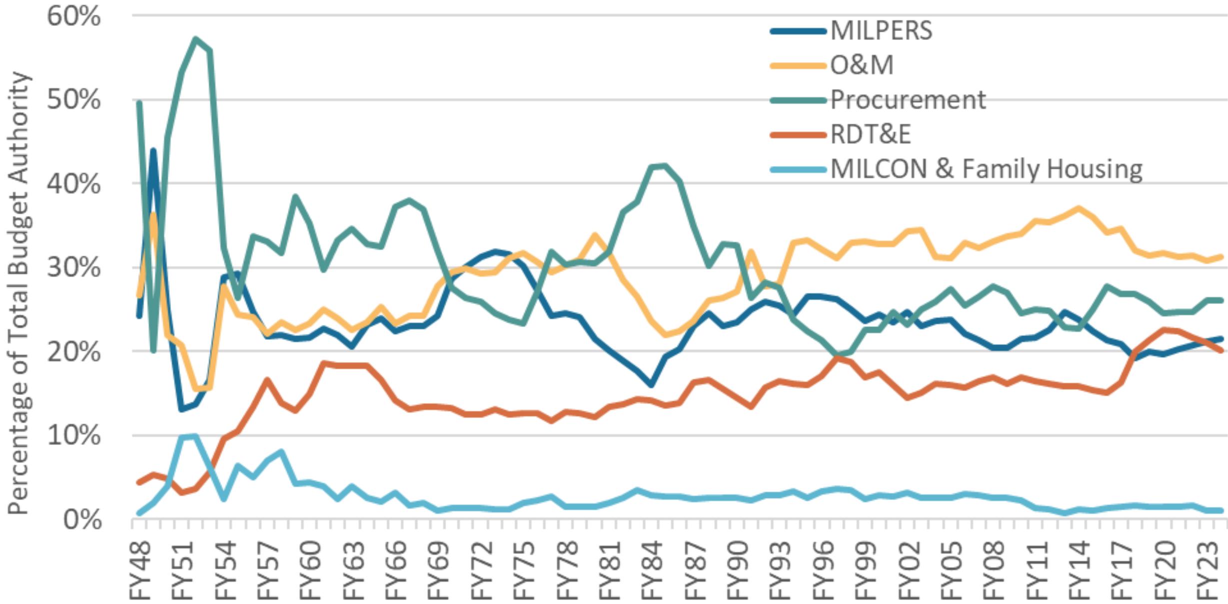
Sources: The data in this figure is from the same data sources used in figures 1-3.

OPERATING COSTS

One of the reasons the force has become smaller while the budget is near an all-time high is that operation and maintenance (O&M) costs have grown faster than other parts of the budget. For example, in the 1980s, the Air Force spent on average 26 percent of its annual budget on O&M, compared to 36 percent for procurement. But in the 2010s, the Air Force spent an average of 35 percent of its budget on O&M, compared to 25 percent for procurement.

7. See: Todd Harrison and Seamus Daniels, *Analysis of the FY 2019 Defense Budget* (Washington, DC: CSIS, September 2018), https://www.csis.org/analysis/analysis-fy-2019-defense-budget.

Figure 5: Share of Air Force Budget Authority by Title

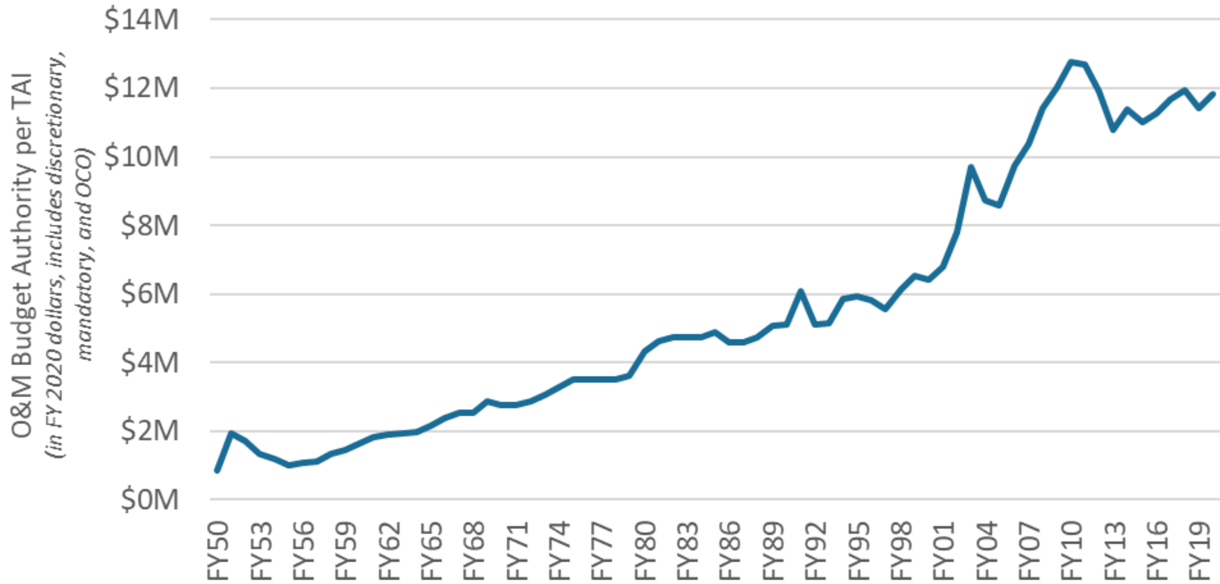


Source: Office of the Under Secretary of Defense (Comptroller), *National Defense Budget Estimates for FY 2020*, May 2019, Table 6-21.

The average O&M cost per aircraft has also increased significantly in recent decades. This is a rough measure of how much it costs to operate the Air Force's fleet of aircraft when normalized for the size of the force. As shown in Figure 6, the average O&M cost per aircraft across the total inventory (adjusted for inflation) has risen steadily over time, and this growth accelerated in the 2000s. While some of the increase in costs was due to the increased pace of operations from the wars in Iraq and Afghanistan, O&M costs did not return to their prewar levels when the pace of these operations began to subside.[8] The average O&M cost per plane is 74 percent higher today in real terms than in FY 2001. Higher aircraft operating costs appear to be the new normal, and historical data suggest that the O&M cost per aircraft may continue to rise in the future.

8. For example, the number of annual sorties flown in Afghanistan fell from 31,049 in 2013 to 12,716 in 2018 for ISR aircraft and 21,900 to 8,196 for crewed strike aircraft. See: "Combined Forces Air Component Commander 2013-2019 Airpower Statistics," United States Air Forces Central Command Combined Air Operations Center, August 31, 2019, https://www.afcent.af.mil/Portals/82/Documents/Airpower%20summary/(U)%20Final%20Aug%202019%20APS%20Data.pdf?ver=2019-09-09-030229-530.

Figure 6: Air Force O&M Cost per Aircraft



Sources: Office of the Under Secretary of Defense (Comptroller), *National Defense Budget Estimates for FY 2020*, May 2019, Table 6-10; James Ruehrmund Jr. and Christopher Bowie, *Arsenal of Airpower: USAF Aircraft Inventory 1950-2016* (Arlington, VA: Mitchell Institute for Aerospace Studies, February 2018).

One possible explanation for the higher O&M costs per plane is the increasing sophistication of modern aircraft. Modern aircraft are generally more expensive to procure due to the advanced components and subsystems that comprise them. Since new aircraft often have higher operating costs, especially in the first few years, the replacement of legacy aircraft with new aircraft can increase overall operating costs. But this explanation does not fully account for the growth in operating costs observed over the past two decades. The cost per flying hour of legacy aircraft also increased during the past two decades, and new aircraft were not added to the fleet in significant numbers. Nearly three-quarters of the Air Force's inventory today is aircraft that were in the inventory 20 years ago.[9]

Another possible explanation for the growth in operating costs is the increasing age of aircraft in the Air Force's inventory. However, a 2018 study by the Congressional Budget Office (CBO) analyzed historical Air Force cost and aircraft age data and did not find evidence to support this. For the nine aircraft types analyzed, the data indicate no significant correlation (a correlation coefficient of 0.14) between the age of aircraft and the annual rate of growth in the cost per flying hour. Instead, the CBO found that growth in the cost per flying hour appears to be correlated with growth in the overall budget. It estimates that the annual rate of growth in operating costs was roughly 0.9 percent higher on average due to the increasing budget.[10] The CBO analysis merely finds a correlation and does not establish a causal relationship between the overall budget and the growth

9. New aircraft that have been added since FY 2000 include the F-22, F-35, CV-22, T-53, T-51, RQ-4, MQ-1, MQ-9, C-37, C-40, various configurations of the C-130J, and most of the C-17s and T-6s. These amount to 1,365 aircraft out of a total of 5,349 in the inventory as of FY 2017.

10. "Operating Costs of Aging Air Force Aircraft," Congressional Budget Office, January 23, 2019, 4–8, https://www.cbo.gov/publication/54926.

in flying hour costs. It could be that the availability of more funding in the overall budget leads to growth in operating costs or that growth in operating costs from other factors, such as deferred maintenance from earlier years, leads to a higher level of overall funding.

Nearly three-quarters of the Air Force's inventory today is aircraft that were in the inventory 20 years ago.

The total O&M cost per aircraft is a broad measure of aircraft operating costs, but a more specific metric commonly used is the cost per flying hour. However, this metric can be confusing—and in some cases misleading—because different cost per flying hour metrics include different costs in the numerator. The narrowest definition commonly used is the flying hour program cost per flying hour. This metric only includes costs that vary directly with the number of hours flown, such as the costs of fuel, other consumables, and depot-level reparables.[11] A slightly broader definition of the cost per flying hour is the reimbursement rate of aircraft, as published each year by the DoD comptroller.[12] The internal DoD reimbursement rate includes all of the costs in the flying hour program plus depot maintenance and variable contractor logistics support. The total reimbursement rate, which is used to charge for non-federal government use of DoD assets, adds in costs that tend to vary directly or indirectly with the number of hours flown, such as aircraft crew salaries, depreciation of the aircraft, and unfunded civilian retirement costs.[13] The total reimbursement rate is typically 7 to 8 percent higher than the internal reimbursement rate.

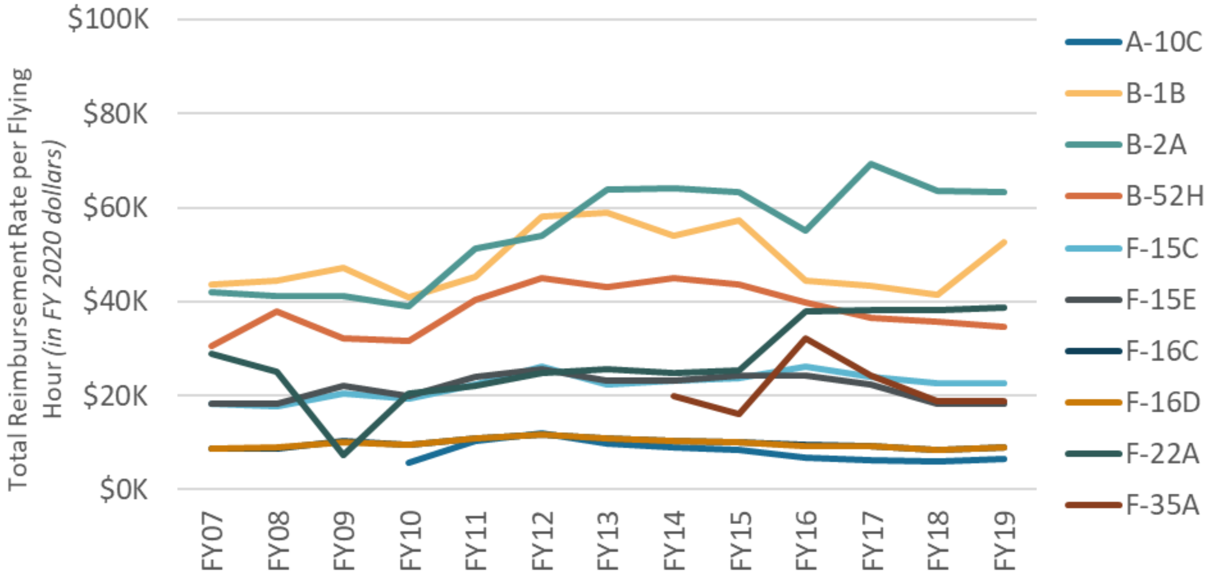
The reimbursement rate varies significantly by type of aircraft and changes over time. As shown in Figure 7, the costs per flying hour for the B-2A bomber and F-22A fighter have risen over the past decade, while the A-10 has declined in recent years. Among airlift and tanker aircraft (Figure 8), the C-5 cost per hour initially spiked with the introduction of the modernized C-5M variant—as is typical for newly introduced aircraft—and costs have declined since then. The outlier in terms of costs, shown in Figure 9, is the E-4B aircraft—a modified 747 used as an airborne command post. Of the Air Force aircraft for which the reimbursable rate is reported, the E-4B has the highest cost at nearly $75,000 per hour. In contrast, the MQ-1B Predator and MQ-9A Reaper have the lowest costs per flying hour in the fleet at less than $800 per hour.

11. Michael Boito et al., *Metrics to Compare Aircraft Operating and Support Costs in DoD* (Santa Monica, CA: RAND, 2015), 13, https://www.rand.org/pubs/research_reports/RR1178.html.

12. The reimbursement rates for each fiscal year can be found at: "Financial Management," Under Secretary of Defense (Comptroller), accessed September 30, 2019, https://comptroller.defense.gov/Financial-Management/Reports/.

13. Boito et al., *Metrics to Compare Aircraft Operating and Support Costs in DoD*, 14-15.

Figure 7: Reimbursement Rate per Flying Hour for Selected Combat Aircraft



Source: Data in figures 7-9 are a compilation of reimbursement rates published by the Office of the Under Secretary of Defense (Comptroller), *Fixed Wing and Helicopter Reimbursement Rates*, for FY 2007 to FY 2019, https://comptroller.defense.gov/Financial-Management/Reports/rates2019/.

Figure 8: Reimbursement Rate per Flying Hour for Selected Airlift and Tanker Aircraft

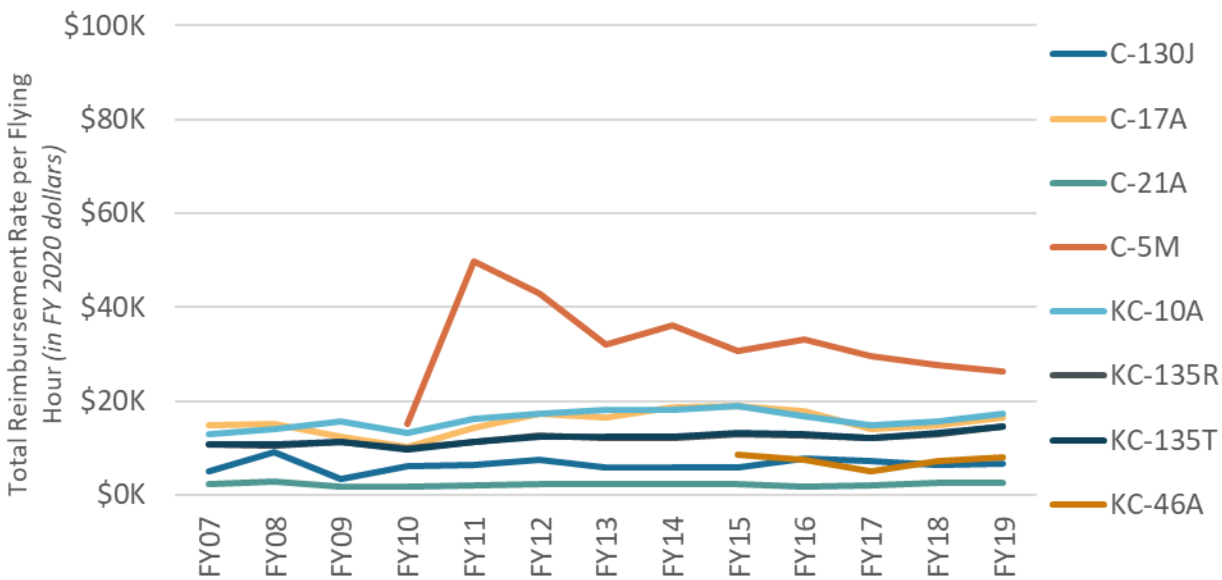
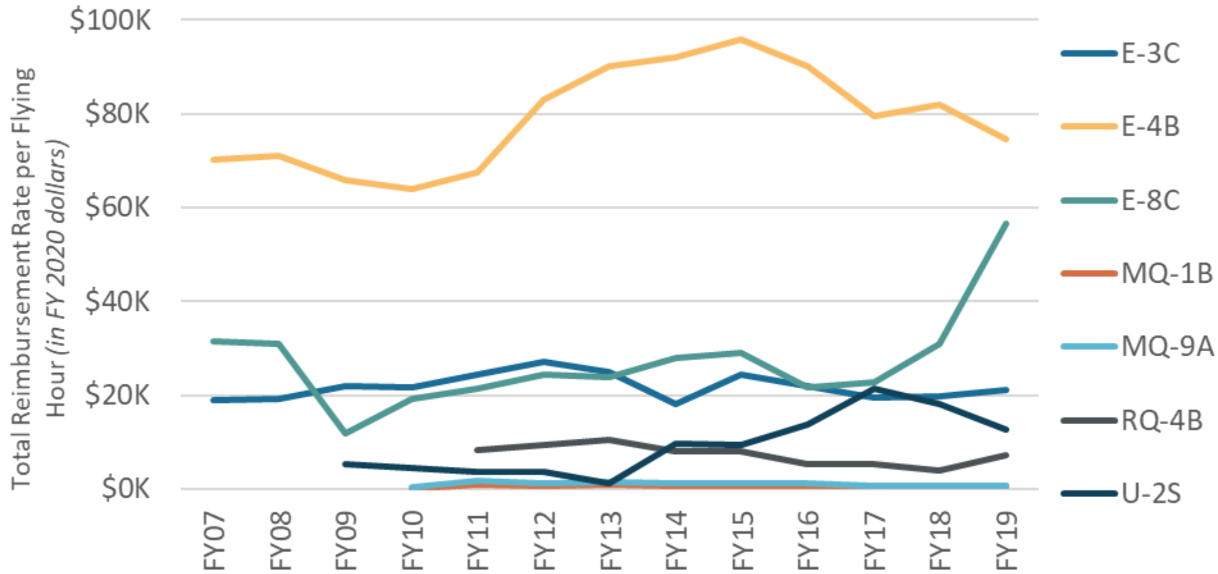


Figure 9: Reimbursement Rate per Flying Hour for Selected ISR/C2 Aircraft



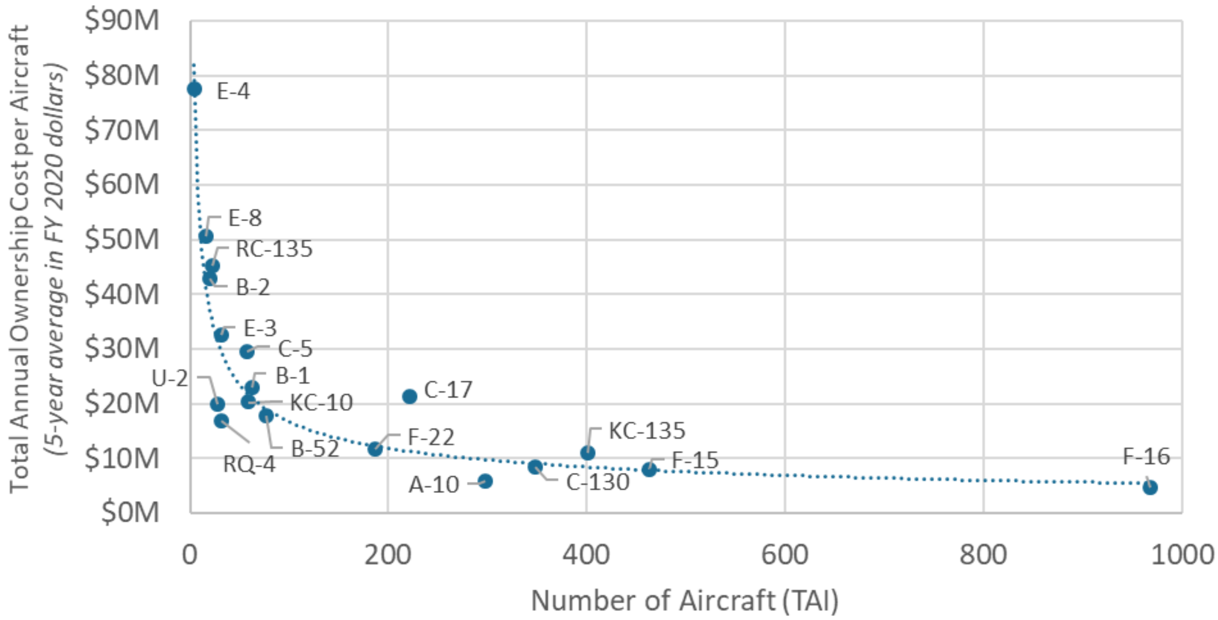
A broader definition of the cost per flying hour is the total aircraft ownership cost per flying hour, which is often used to make cross-platform comparisons of costs.[14] This includes the variable costs described above, as well as fixed support costs that do not vary with the number of hours flown, such as unit-level support personnel, sustaining engineering, software maintenance, and platform modifications and upgrades. However, this cost per flying hour can be misleading because the fixed portion of the costs are significant—often larger than the variable costs. If fewer hours are flown in a particular year, the fixed costs get distributed across a smaller number of flying hours, which causes the total ownership cost per flying hour to increase—a dynamic that can be counterintuitive. Likewise, when a type of aircraft is going through a modernization program, its fixed costs will be temporarily higher, causing its cost per flying hour to increase.

A metric that better captures both the fixed and variable costs of aircraft without these unintended effects is the annual total ownership cost per aircraft. The unclassified summary of the MITRE force structure study devotes a section to an analysis of the total ownership cost per aircraft, and a notable conclusion it makes is that total ownership cost is inversely correlated with the number of aircraft of a type in the inventory. As shown in Figure 10, small fleets of aircraft (like the E-4, E-8, and B-2) tend to have a much higher ownership cost per plane than aircraft that are operated in larger numbers (like the F-15 and F-16). This is because the fixed costs of operating the fleet are distributed across more aircraft in large fleets, which brings down the overall ownership cost per plane. As the MITRE study notes, the knee in the curve is around 150 aircraft.[15] The data suggest that the Air Force could reduce operating costs by divesting aircraft that are maintained in small numbers in the current inventory and consolidating the capabilities they provide into common multi-mission platforms. But this approach only works for aircraft types where the basic aircraft capabilities needed are common across multiple platforms.

14. Ibid., 17.

15. MITRE Corporation, *U.S. Air Force Aircraft Inventory Study Executive Summary* (McLean, VA: September 2019), 5-6, https://aerospace.csis.org/wp-content/uploads/2019/09/MITRE-AF-Summary.pdf.

Figure 10: Annual Total Ownership Cost per Aircraft



Source: In a footnote on page 6, the MITRE study references analysis performed by the Northrop Grumman Analysis Center that was verified by MITRE. The author independently obtained the same data and adjusted it to FY 2020 dollars to produce this figure.

ACQUISITION

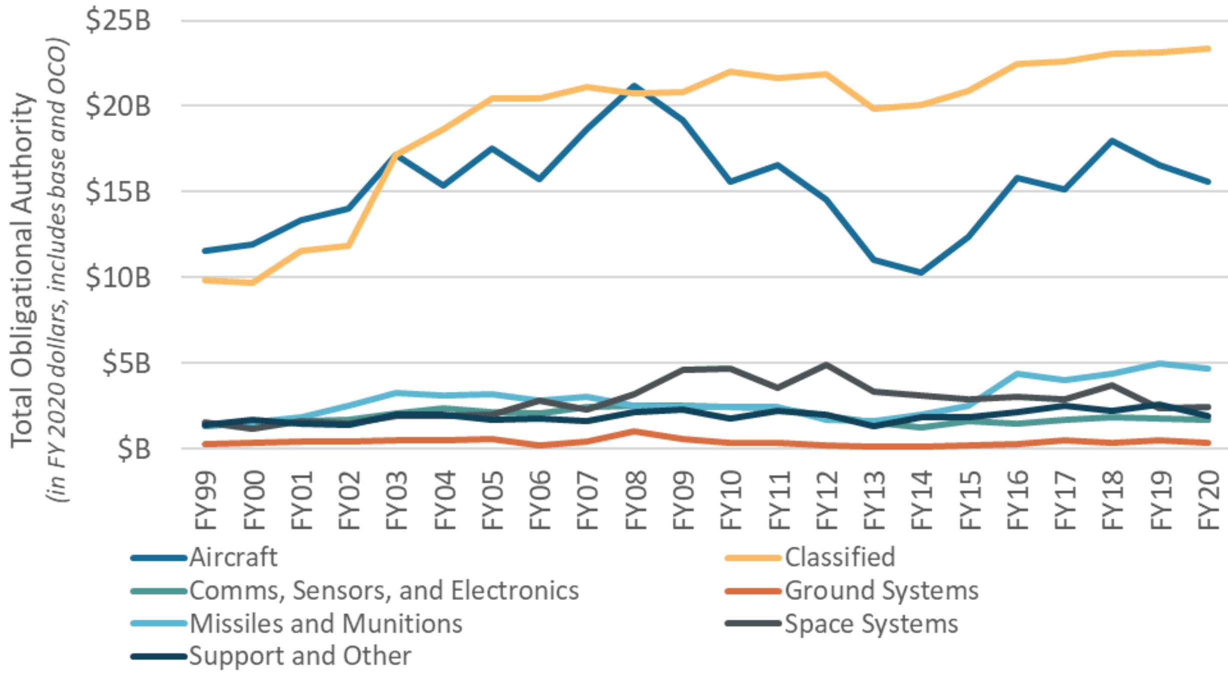
The Air Force is amid several major acquisition programs that are key to building its future force structure. It has made clear that its top three acquisition priorities are the F-35A, B-21, and KC-46A programs.[16] But it also plans to replace the current fleet of ICBMs through the Ground Based Strategic Deterrent (GBSD) program, buy a new fleet of training aircraft (T-7A), and develop the Next Generation Overhead Persistent Infrared (Next-Gen OPIR) missile warning satellites, among other major acquisition programs planned or currently underway. The challenge for the Air Force is to simultaneously fund and execute these programs while managing all of the other pressures on its budget.

Historically, the Air Force's procurement budget has been highly cyclic. Over the past two decades, however, this trend has been altered by the growth of classified funding within the Air Force's procurement accounts. As shown in Figure 11, classified procurement funding more than doubled in real terms over the past 20 years. Even during the overall defense budget downturn from FY 2010 to FY 2015, the Air Force's classified procurement funding was largely unscathed. In contrast, aircraft procurement funding was cut by half from FY 2008 to FY 2014 as procurements of the F-22, C-17, and other major programs came to an end and F-35 procurements were delayed. Aircraft procurement funding has since recovered somewhat, but since FY 2010, the Navy has spent more each year on aircraft procurement than the Air Force.[17]

16. Jeremiah Gertler, "Air Force B-21 Raider Long-Range Strike Bomber," Congressional Research Service, October 12, 2018, 1, https://fas.org/sgp/crs/weapons/R44463.pdf.

17. Harrison and Daniels, *Analysis of the FY 2019 Defense Budget*, 20.

Figure 11: Total Air Force Procurement Funding



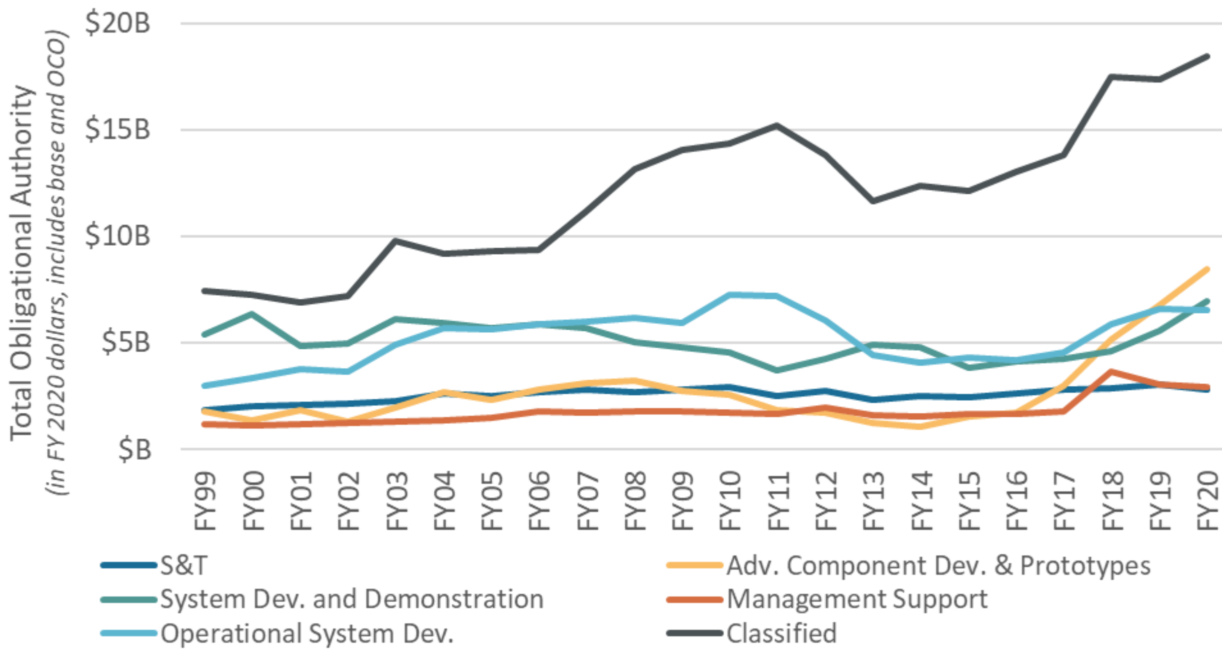
Source: Data compiled from the annual P-1 procurement budget documents published by the Office of the Under Secretary of Defense (Comptroller) for FY 2001 to FY 2020. Each line item of data was categorized by the author and aggregated for analysis.

The Air Force's budget for research, development, test, and evaluation (RDT&E) has experienced some of the same trends. As shown in Figure 12, classified Air Force RDT&E funding grew by 52 percent in real terms over the past five years to a record high of $18.4 billion in the FY 2020 request. Funding for advanced component development and prototypes (budget activity 6.4) also grew significantly over the same period, reaching $8.5 billion in the FY 2020 request. Growth in these accounts indicate that new start programs, such as the B-21 and GBSD, are beginning to work their way through the acquisition system after a dearth of new starts in the early-2010s.

Much of the classified funding in the Air Force's procurement and RDT&E accounts is presumably pass-through funding. Pass-through funding is money that is appropriated in Air Force accounts but passes through to other organizations. Funding for the National Reconnaissance Office (NRO), for example, does not appear in the president's annual budget request but presumably is funded through classified accounts. While each of the military services have classified funding lines of their own, the Air Force has more classified funding than the other services. The Air Force provides a breakout in its budget request summary of the total pass-through funding, which totals $39 billion in the FY 2020 request, but it does not indicate specifically which funding lines and accounts are pass-through or what this money is used for.[18]

18. United States Air Force, *Fiscal Year 2020 Budget Overview* (Washington, DC: March 2019), 5,https://www.saffm.hq.af.mil/Portals/84/documents/FY20/FY2020%20Air%20Force%20Budget%20Overview%20Book%20Final%20v3.pdf?ver=2019-03-13-082653-843.

Figure 12: Total Air Force RDT&E Funding



Source: Data compiled from the annual R-1 RDT&E budget documents published by the Office of the Under Secretary of Defense (Comptroller) for FY 2001 to FY 2020.

READINESS AND OPERATIONAL TEMPO

Another important factor when assessing the current state of the Air Force is the readiness and operational tempo (OPTEMPO) of the force. The readiness metrics used in the Defense Readiness Reporting System (DRRS) attempt to estimate readiness using proxy measures, such as the inputs used to generate readiness. These input metrics assess the number of qualified personnel, the quantities of equipment and supplies on hand, the amount of maintenance performed, and the volume of training conducted. Each of these factors is measured against a set of self-determined standard levels for adequacy. These metrics do not, however, assess the quality of the inputs, the sufficiency of the standards being used, the operational capabilities of the force, or how effectively these inputs are used to generate mission-ready forces.[19]

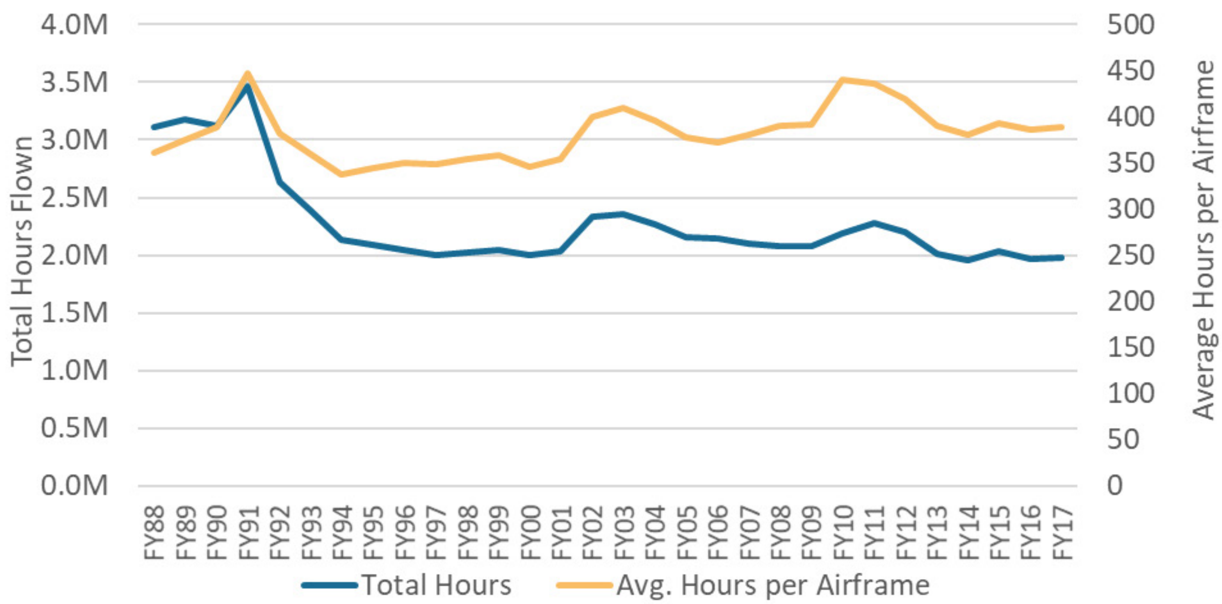
While unit-level metrics that assess the readiness of forces to perform the missions assigned to them are not available publicly, some high-level metrics can shed light on the overall readiness and OPTEMPO of the Air Force relative to previous periods—although even these measures are far from comprehensive. Metrics that are publicly available and used in this analysis include: total flying hours of the force, average flying hours per aircraft, mission capable rates, and mishap rates.

Figure 13 shows the total number of annual flying hours over the past 30 years for 43 different aircraft that collectively include more than 90 percent of the Air Force's inventory. As one would expect, the total number of flying hours for the force declined at the end of the Cold War in

19. For more on readiness metrics and the shortfalls of the current readiness measurement system, see: Todd Harrison, "Rethinking Readiness," *Strategic Studies Quarterly* 8, no. 3 (Fall 2014): 38-68, https://www.airuniversity.af.edu/Portals/10/SSQ/documents/Volume-08_Issue-3/Harrison.pdf.

proportion to the overall reduction in the size of the force. The total number of flying hours has stayed relatively flat since the mid-1990s, except for temporary increases for the opening phases of the wars in Afghanistan and Iraq in 2002 and 2003, respectively, and the overlapping surges in Afghanistan and Iraq in 2010 and 2011, respectively.

Figure 13: Air Force Total Flying Hours and Average Hours per Airframe



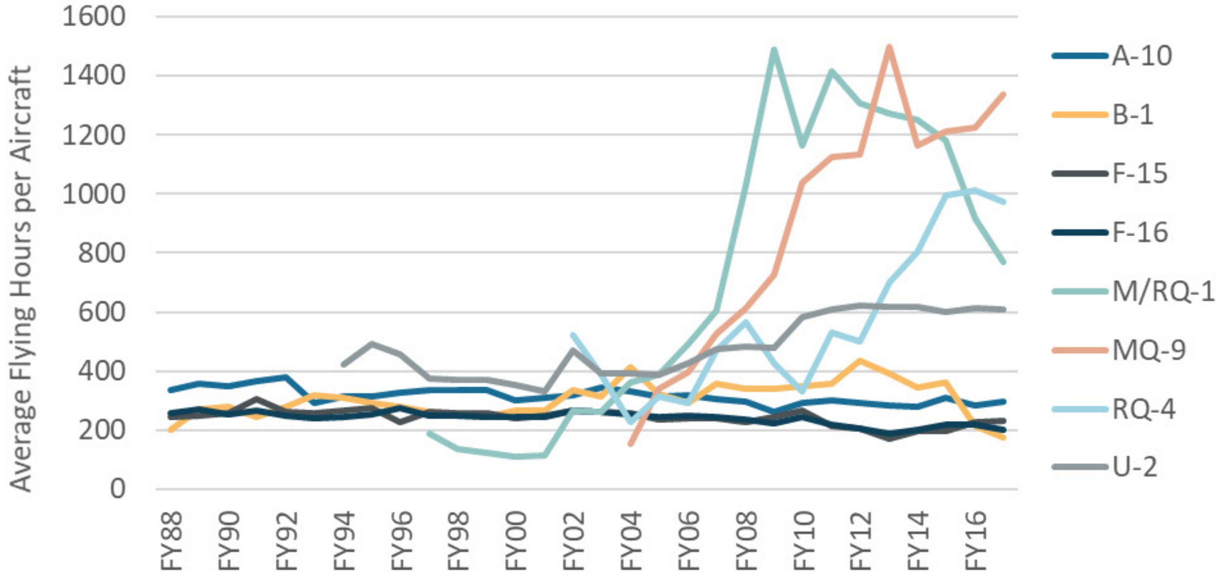
Source: Data compiled from Air Force Safety Center Aviation Statistics for all aircraft reported, https://www.safety.af.mil/Divisions/Aviation-Safety-Division/Aviation-Statistics/.

A better measure of the overall OPTEMPO and the stress on the force is the average number of annual flying hours per airframe, also shown in Figure 13. The annual flying hours per airframe has trended up slightly since the mid-1990s, but it remains within historical norms. Even the increases in flying hours per airframe for operations in Iraq and Afghanistan were relatively small—up 7 percent in FY 2003 and 13 percent in FY 2010 from the historical trendline.

Some types of aircraft, however, have experienced higher than normal usage in recent years. For example, the B-1 stands out among combat aircraft as being a workhorse for operations in Afghanistan and Iraq. During the 1990s, the B-1 averaged 276 annual hours per airframe, but from FY 2002 to FY 2015 it averaged 354 hours, an increase of 28 percent. In contrast, annual flying hours per airframe for the A-10 have generally declined, averaging 335 hours per airframe in the 1990s, compared to 292 hours from FY 2010 to FY 2017.

Among intelligence, surveillance, and reconnaissance (ISR) and command and control (C2) aircraft, remotely piloted aircraft (RPAs) have a higher utilization rate than crewed aircraft. For example, the RQ-4 averaged 898 annual hours per airframe from FY 2013 to FY 2017, while the U-2 averaged 611 hours over the same period. The M/RQ-1 and MQ-9 have the highest utilization rates of any aircraft in the Air Force inventory, averaging 1,079 and 1,288 hours per airframe, respectively, from FY 2013 to FY 2017. To put it in perspective, the average MQ-9 airframe flies more than four times as much each year as the average A-10 and more than six times as much as the average F-15 and F-16—and the MQ-9's reimbursement rate is roughly a tenth or less of the cost of these other aircraft.

Figure 14: Average Flying Hours per Airframe for Selected Platforms



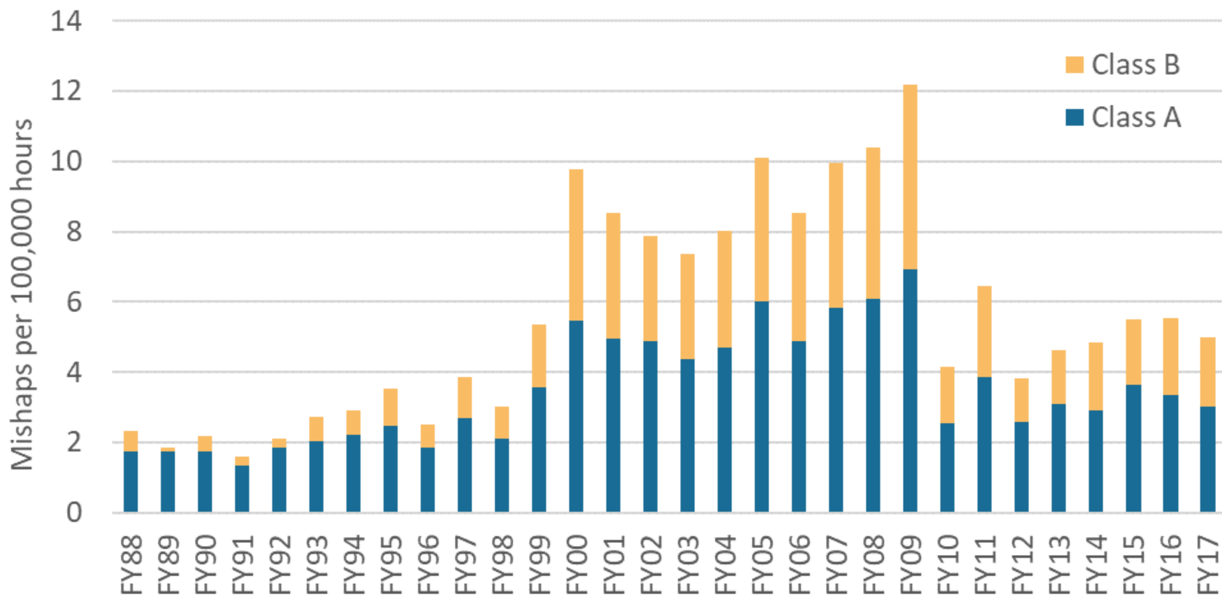
Source: Flying hour data from Air Force Safety Center Aviation Statistics, and inventory data from James Ruehrmund Jr. and Christopher Bowie, *Arsenal of Airpower: USAF Aircraft Inventory 1950-2016* (Arlington, VA: Mitchell Institute for Aerospace Studies, February 2018).

Another measure of readiness (or the lack thereof) is the mishap rate, expressed as the number of Class A and B mishaps per 100,000 flying hours.[20] The overall mishap rate was three times higher on average in the 2000s than it was in the 1990s. One of the main contributors to the higher mishap rate was the B-1: it accounted for 9 percent of all the Class A and B mishaps during the 2000s but only 1 percent of the hours flown. The higher mishap rate could be due to Afghanistan and Iraq, which involved more dangerous operations than in peacetime. And although the mishap rate returned to a lower level in the 2010s, due in part to a change in the threshold for reporting Class A mishaps, it remains nearly double what it was in the 1990s.[21] The surge in mishaps during the 2000s and the higher steady-state level since then suggest that the Air Force has more readiness issues now affecting the safe operation of aircraft than it had in the 1990s.

20. A Class A mishap involves the destruction of an aircraft, a fatality or permanent total disability of a person, or property damage of $2,000,000 or more. A Class B mishap involves property damage between $500,000 and $2,000,000, permanent partial disability of a person, or three or more persons hospitalized as inpatients. For more details on mishap types, see: "Current Mishap Definitions and Reporting Criteria," U.S. Naval Safety Center, U.S. Navy, accessed September 30, 2019, https://www.public.navy.mil/NAVSAFECEN/Pages/statistics/mishap_def.aspx.

21. The threshold for a Class A mishap changed on October 1, 2009 from $1,000,000 to $2,000,000. See: Department of the Navy, *Final Environmental Impact Statement for the East Coast Basing of the F-35B* (Washington, DC: October 2010), 5-44, https://www.beaufort.marines.mil/Portals/53/Docs/Volume_I_Final_EIS.pdf.

Figure 15: Mishap Rates for Air Force Aircraft



Source: Data compiled from Air Force Safety Center Aviation Statistics for all aircraft reported.

The mission capable rate is a measure of the fraction of time aircraft are ready to perform the missions assigned to them. Data for mission capable rates, obtained for FY 2014 to FY 2018, show that the overall mission capable rate of equipment is declining. The composite mission capable rate for all Air Force aircraft fell steadily from 73.7 percent in FY 2014 to 70.0 percent in FY 2018. Of the 35 different platform types for which data was available, shown in Figure 16, 29 have an average mission capable rate less than 80 percent. The MQ-9 was the only platform with a mission capable rate that increased in each year, climbing from 86.1 percent in FY 2014 to 90.2 percent in FY 2018. The aircraft with an average mission capable rate above the 80 percent target in the five years analyzed were the MQ-1B, MQ-9A, MC-130J, C-17A, AC-130U, and UH-1N.[22] As shown in Figure 17, the mission capable rate continues to decline for most Air Force aircraft. From FY 2017 to FY 2018, the T-6A, E-3G, and CV-22B saw the largest declines in mission capable rates, while the B-2A and AC-130U made the largest improvements. Importantly, analysis of the data did not find a correlation between mission capable rates and the average age of aircraft or the size of the aircraft fleet. For example, the F-35A and CV-22B are among the newest aircraft in the fleet, yet they have among the lowest mission capable rates.

Of the 35 different platform types for which data was available, 29 have an average mission capable rate less than 80 percent.

22. Former Secretary of Defense James Mattis issued a memo on September 17, 2018 that established an 80 percent mission capable rate as the target for certain fighter/attack aircraft. See: Sam LaGrone, "SECDEF Mattis Wants 80 Percent of Super Hornets Mission Capable by Next Year," USNI News, October 9, 2018, https://news.usni.org/2018/10/09/secdef-mattis-wants-80-percent-super-hornet-mission-capable-next-year.

Figure 16: Air Force Mission Capable Rates for Selected Aircraft

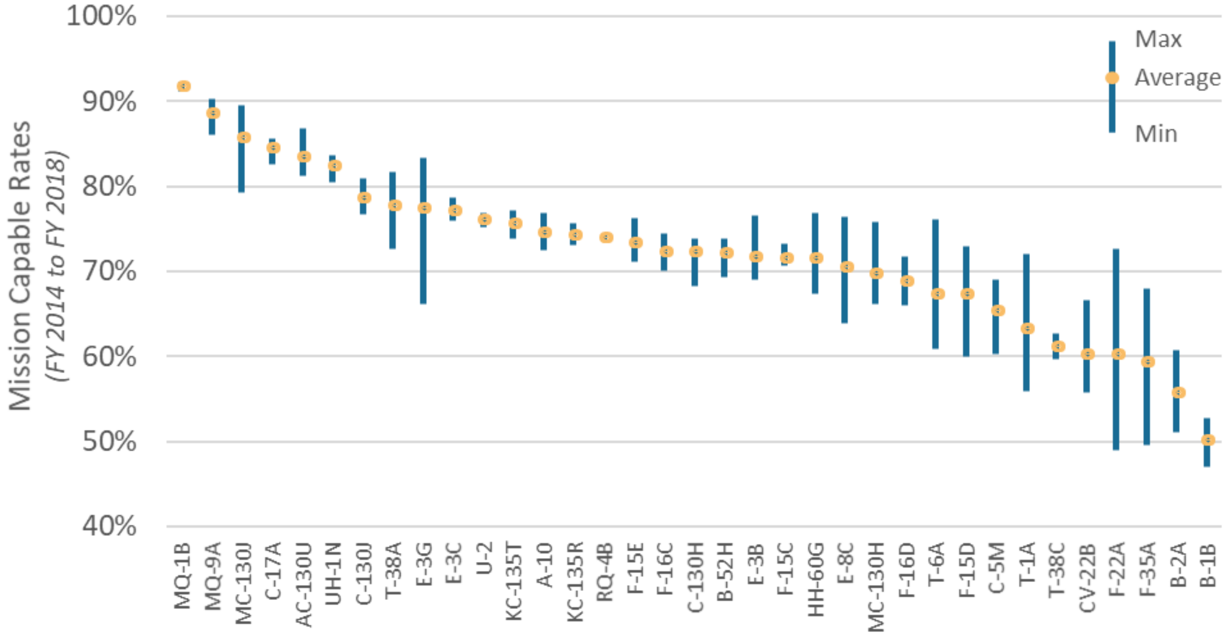
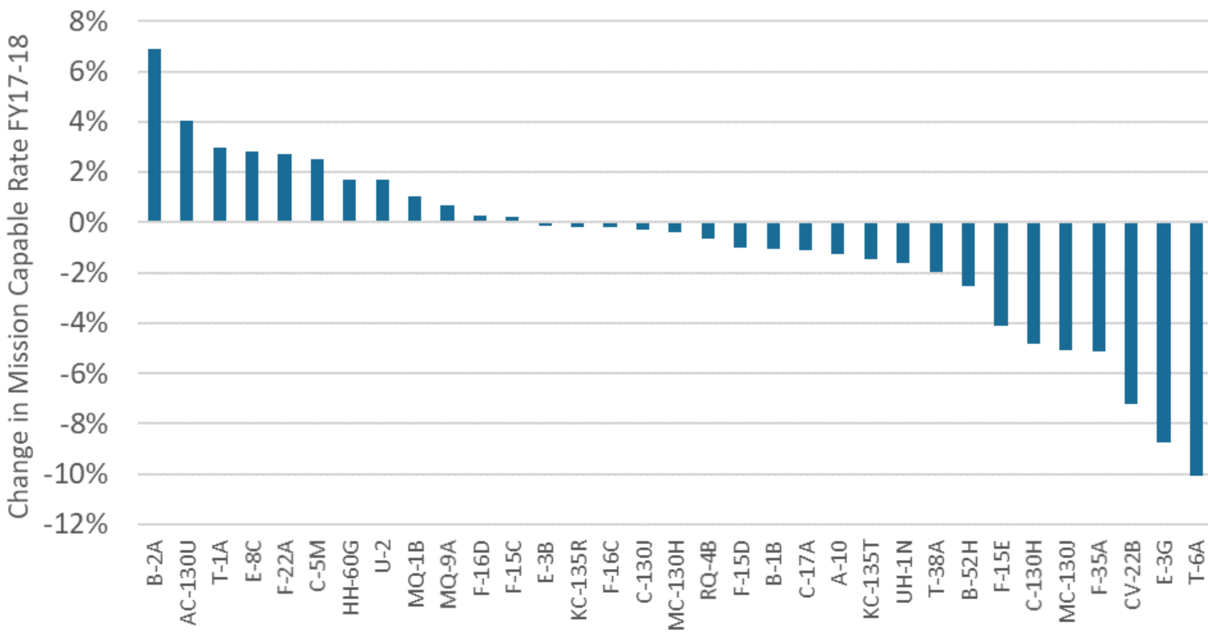


Figure 17: Change in Mission Capable Rate from FY 2017 to FY 2018



Source: Data in figures 16 and 17 obtained from Stephen Losey, "Growing Readiness Woes: Only 7 in 10 Air Force Planes Are Ready to Fly," Air Force Times, August 7, 2017, https://www.airforcetimes.com/news/your-air-force/2017/04/02/growing-readiness-woes-only-7-in-10-air-force-planes-are-ready-to-fly/;and Stephen Losey, "Aircraft Mission-Capable Rates Hit New Low in Air Force, despite Efforts to Improve," Air Force Times, August 1, 2019, https://www.airforcetimes.com/news/your-air-force/2019/07/26/aircraft-mission-capable-rates-hit-new-low-in-air-force-despite-efforts-to-improve/.

CONCLUSIONS

The current state of the Air Force is much like a power-on stall in an airplane. Despite the Air Force's budget being at full throttle and near record levels, it has fewer aircraft and personnel, accomplishes fewer flying hours in total each year, has a declining mission capable rate, and has a higher mishap rate. One of the main drivers behind the Air Force's current situation is the rising costs of operating aircraft. As this analysis demonstrates, higher operating costs are not primarily due to aging aircraft or a higher OPTEMPO. In fact, the increase in OPTEMPO (whether measured by the total number of flying hours for the force or the average number of flying hours per platform) has been relatively minor and concentrated on just a handful of platforms, such as the B-1, M/RQ-1, and MQ-9. The Air Force also experienced an increase in the aircraft mishap rate and a decrease in the mission capable rate, which together suggest broader issues with training and maintenance.

For the Air Force to pull out of this stall without going into a tailspin, it needs to re-evaluate its planned force structure, the new capabilities it is fielding, and the mix of legacy aircraft that will remain in its inventory. While the strategic priorities of the NDS should guide this evaluation, there are some changes the Air Force can make that are independent of strategy. The data show that small fleets of aircraft are expensive to operate and maintain. Combining small fleets of specialized platforms into larger fleets of multi-mission platforms when possible could potentially reduce overall operating costs. The data also show that the RPAs currently in the inventory have a higher utilization rate, higher mission capable rate, and lower flying hour cost than their crewed counterparts. This experience should be factored into decisions about which future platforms should be crewed versus remotely or autonomously operated.

02

Comparing the Studies

Congress mandated the three independent studies on the Air Force's future force structure to address the current state of the Air Force and the challenges it faces over the next 10 years. The legislation specifically requires the studies to evaluate "opportunities for reduced operation and sustainment costs" and "the role of evolving technology on future air forces, including unmanned and space systems."[23] With this in mind, the sections below compare and contrast the studies based on: the scope and assumptions they use; the future operating environment they envision; the force planning scenarios and sizing constructs they employ; the key missions and capabilities they prioritize; and the number and types of aircraft they recommend for the 2030 force.

SCOPE AND ASSUMPTIONS

The studies have many of the same underlying assumptions and are similar in scope, but they differ in some important ways. For example, the studies did not all use the same time horizon for analysis. The FY 2018 NDAA required that the three studies "analyze alternative aircraft inventories through 2030" and develop associated force sizing constructs to justify these inventories. Both the Air Force and MITRE studies stick to this mandate closely, focusing on the size and mix of capabilities in 2030. The CSBA study, however, goes a step farther by also analyzing what would be needed in a future force beyond 2030 to account for new capabilities that would not be ready in significant quantities until the mid- to late-2030s.

The MITRE and CSBA studies focus on the aviation force structure of the Air Force rather than the total force structure, including intercontinental ballistic missile (ICBM) and space forces. This is consistent with the legislation, which specifically mandated an analysis of aircraft inventories. The Air Force's study, however, also includes ICBM, cyber, and space forces in its analysis, although it provides little detail on cyber and space forces. It lumps all of the different types of space operational units into one generic category of "squadron equivalent" space units. The MITRE study focuses relatively more on basing issues and includes options for additional basing locations and capacity as part of its analysis.

The Air Force analysis also differs from the others in some of the overarching assumptions made. First, the Air Force study is not limited by budget constraints or consideration for what resources might reasonably be available in the future.[24] It also assumes that the current program of record "can deliver as planned to either fill capacity or capability gaps in the current force," and it does not

23. National Defense Authorization Act for Fiscal Year 2018.

24. U.S. Air Force, *Fiscal Year 2018 National Defense Authorization Act (NDAA) Section 1064 Study: Aircraft Inventories for the Air Force* (Washington, DC: March 2019), 2, https://aerospace.csis.org/wp-content/uploads/2019/09/Air-Force-FY18-NDAA-Section-1064-Study.pdf.

consider "new solutions" or "game-changing technologies."[25] Moreover, the study is limited to the current ratios of active and reserve component forces, meaning that it does not consider options to shift certain parts of the force more or less into the guard and reserve.[26] The net effect of these assumptions is that the Air Force analysis is inherently constrained to solutions that grow the current force structure and program of record. These assumptions limit its ability to explore options that would fundamentally rebalance the force, cut or reduce elements of the force, enable new operational concepts, or significantly alter modernization investments.

The studies also differ significantly in the length and level of detail provided in the unclassified reports. At 158 pages in length (not including appendices), the CSBA study provides the greatest level of detail, including tables with proposed aircraft inventories by aircraft model and a detailed description of the methodology used. In contrast, the Air Force and MITRE unclassified reports are just 6 and 12 pages in length, respectively, and provide much less detail. The Air Force only reports the proposed force structure in numbers of squadrons and by broad categories of aircraft, such as fighters and bombers rather than F-35s and B-52s. It also provides little insight into its methodology and the planning assumptions used to arrive at the number of squadrons proposed. The MITRE unclassified report provides some details on its proposed changes to force structure by type of aircraft rather than broad categories, but it does not present the same level of detailed analysis as the CSBA study. For this reason, the following comparative analysis provides relatively more discussion of the CSBA study results than the Air Force and MITRE studies. This merely reflects the availability of information and should not be construed as a measure of merit or an implicit endorsement.

FUTURE OPERATING ENVIRONMENT

All of the studies agree that the future operating environment will be more contested and that the most stressing scenarios for which the force must be designed involve Russia and China. Moreover, in an era of great power competition, timelines may be compressed, with fewer indications and warnings prior to conflict initiation, which drives the need for more flexible and dynamic operational concepts for how forces are employed.[27] Of the three studies, the Air Force provides the least insight into its assumptions about the future operating environment, beyond noting that "our adversaries are investing in their militaries and advanced technologies" and that "the threat is rapidly evolving."[28]

Both the CSBA and MITRE studies pay special attention to the threats posed to air bases by adversary missile forces. The MITRE study notes that anti-access/area-denial (A2/AD) capabilities can be used to destroy forward-based aircraft on the ground or on ship decks, making forward bases "tempting targets for enemy A2/AD systems." It goes on to conclude that currently, "there are insufficient bases and logistical infrastructure to conduct large-scale operations from

25. Ibid., 2-3.

26. Ibid., 2.

27. For an example of this, see: General Lori Robinson, statement before the Senate Armed Services Committee, February 15, 2018, 11, http://www.northcom.mil/Portals/28/Robinson_02-15-18%20SASC%20Testimony.pdf?ver=2018-02-15-105546-867.

28. U.S. Air Force, *Fiscal Year 2018 National Defense Authorization Act (NDAA) Section 1064 Study*, 1.

geographically lower risk, more distant middle-tier and rear bases."[29] The CSBA study generally agrees with this assessment. It finds that "large salvos of precision weapons could result in significant attrition to U.S. air forces on the ground and severe damage to fuel tanks, munitions storage areas, and other critical enablers."[30]

Another widely acknowledged aspect of the future operating environment is the increasing capability of adversary integrated air defense systems (IADS). Advanced, long-range IADS can force non-stealthy aircraft to operate at greater standoff ranges. Non-stealthy aircraft can still contribute in a highly contested environment, however, by employing longer-range standoff weapons and sensors and using support from off-board electronic warfare systems to confuse adversary IADS. The CSBA study calls this a form of "virtual attrition" because it forces planners to allocate more aircraft to missions and limits the overall striking capacity of the force. CSBA also notes that even stealthy aircraft are affected by these threats because they must plan their routes to avoid high-threat areas and may require more support from electronic warfare aircraft and additional munitions to suppress advanced IADS.[31]

Space, cyber, and electronic warfare threats also present challenges to air operations due to how dependent U.S. air power has become on space-based ISR, satellite communications, and terrestrial information networks to complete the sensor-to-shooter kill chain. The CSBA study finds that "effectiveness in the battlespace increasingly hinges on the ability of a modern military to collect, manage, analyze, and exploit information faster and more accurately than an adversary." It notes that potential adversaries, particularly Russia and China, have invested heavily in electronic warfare, counterspace, and cyber capabilities with the intent to challenge and disrupt U.S. information dominance.[32] The study also finds that non-kinetic or kinetic forms of attack can be used to disrupt command, control, communications, computer, intelligence, surveillance, and reconnaissance (C4ISR) and military logistics hubs, as well as civilian infrastructure, within the United States.

FORCE PLANNING SCENARIOS AND SIZING CONSTRUCTS

Given the projected future operating environment, each of the studies uses different planning scenarios and force sizing constructs to determine the number and mix of aircraft needed in the future force. The Air Force study uses combatant command operational plans and jointly-developed scenarios, but because these plans are classified, it does not elaborate on which specific scenarios are used. The unclassified report notes that the analysis focused on the aircraft inventories needed for scenarios with "the highest demands on the Air Force component."[33]

The Air Force uses a force sizing construct based on the 2018 National Defense Strategy, which calls for a different combination of missions during peacetime competition and wartime. In peacetime, the force should be sized to simultaneously: (1) defend the homeland; (2) deter nuclear and non-nuclear

29. MITRE Corporation, *U.S. Air Force Aircraft Inventory Study Executive Summary*, 4.

30. Mark Gunzinger et al., *An Air Force for an Era of Great Power Competition* (Washington, DC: Center for Strategic and Budgetary Assessments, March 29, 2019), 37, https://csbaonline.org/uploads/documents/CSBA_AF-AIS_Report_v9.pdf.

31. Ibid., 42.

32. Ibid., 47.

33. U.S. Air Force, *Fiscal Year 2018 National Defense Authorization Act (NDAA) Section 1064 Study*, 2.

strategic attack; (3) deter aggression in three theaters; (4) degrade terrorist and weapons of mass disruption threats; and (5) defend U.S. interests below the threshold of armed conflict. In wartime, the force should be sized to simultaneously: (1) defend the homeland; (2) deter nuclear and non-nuclear strategic attack; (3) defeat aggression by a major power; (4) deter opportunistic aggression in a second theater; and (5) disrupt terrorist and weapons of mass disruption threats. When aggregating the results, the Air Force analysis used the maximum projected demand from either the wartime or peacetime constructs for each category of force structure.

Figure 18: Air Force Study Force Sizing Construct

<table>
<tr><th>Competition</th><th>War</th></tr>
<tr><td colspan="2">Defend the Homeland</td></tr>
<tr><td colspan="2">Deter Nuclear and Non-Nuclear Attack</td></tr>
<tr><td>Deter Aggression in Three Theaters</td><td rowspan="2">Defeat Aggression by a Major Power</td></tr>
<tr><td>Degrade Terror & WMD Threats</td></tr>
<tr><td rowspan="2">Defend U.S. Interest Below Armed Conflict</td><td>Deter Opportunistic Aggression in Second Theater</td></tr>
<tr><td>Disrupt Terror & WMD Threats</td></tr>
</table>

Source: U.S. Air Force, *Fiscal Year 2018 National Defense Authorization Act (NDAA) Section 1064 Study*.

The MITRE study provides limited insights into the planning scenarios and force sizing construct used for its analysis. The report states that its analysis had a "primary focus on meeting the demands of sustained, high-intensity combat operations in the Indo-Pacific theater" and that "theoretical battles in this region represent stressing scenarios useful for planning the 2030 Air Force." It does not mention other scenarios or missions that were considered, such as a Russia scenario or steady-state nuclear deterrence and homeland defense missions. The MITRE team developed an aircraft "beddown" optimization model for the Indo-Pacific region that accounted for "geography, threats to bases, base defenses, aircraft payloads, and scenario-based mission taskings," which suggests a high degree of precision and replicability in the analysis, even if the scope of scenarios and missions was more limited.[34]

The CSBA study provides the most detail on the planning scenarios and force sizing construct used in its analysis. It includes three primary mission areas (strategic deterrence, homeland defense, and defeat great power aggression) and three secondary mission areas (conflict with a regional aggressor, long-term peacetime competition, and counterterrorism operations).[35] Because the strategic deterrence mission area is arguably the highest priority for the Air Force, the CSBA

34. MITRE Corporation, *U.S. Air Force Aircraft Inventory Study Executive Summary*, 3.

35. Gunzinger et al., *An Air Force for an Era of Great Power Competition*, 58-59.

construct assumes that platforms set aside for the strategic deterrence mission are not available for other contingencies. This includes some nuclear-capable bombers, some dual-capable fighters, the ICBM force, and a sufficient contingent of supporting platforms, such as aerial refueling tankers and command and control aircraft.[36] The CSBA study also includes forces for the homeland defense mission, which includes aerospace control operations, airborne cruise missile defense, and airlift and other operations to support civil authorities.[37]

However, the main driver of force structure in the CSBA planning construct is the ability to defeat great power aggression from both Russia and China nearly simultaneously. In a notable departure from the Air Force study, the CSBA construct contends that it is not sufficient to merely keep enough forces in reserve for a "temporary holding action" against a second major power if the United States is already in a conflict with one major power. Rather, the Air Force will need sufficient forces "to support a decisive operation" against a second opportunistic aggressor.[38] This assumption has the effect of increasing the demand for force structure, and it is different than the Air Force's interpretation of the National Defense Strategy, which calls for a force capable of defeating one great power while simultaneously deterring opportunistic aggression by another.

The CSBA analysis of the forces needed for great power competition uses two specific pacing scenarios: a conflict with China in the South China Sea and a near-simultaneous Russian military incursion into the Baltic states. The South China Sea scenario assumes that it begins with gray zone activities in the East China Sea that escalate into Chinese seizure of islands and the establishment of "military dominance" over areas in the South China Sea.[39] The European scenario assumes a Russian invasion of Lithuania to secure a land bridge between Belarus and Kaliningrad and to cut off NATO access to the Baltic states.[40] It stipulates that the United States would have seven days warning before the Chinese incursion and five days warning before the Russian invasion. It further assumes that the Russian conflict would begin first and that the Chinese conflict would begin 10 to 20 days later.[41] Notably, it recommends that the Air Force should not assume that it will be able to swing significant numbers of "aircraft that are engaged in one peer-to-peer conflict to another theater to deter or defeat aggression by another great power."[42] These assumptions on the simultaneity of the two major wars and the inability to swing forces between theaters makes the force requirements higher than they would be otherwise.

The CSBA study assumes that the secondary mission areas (conflict with a regional aggressor, long-term peacetime competition, and counterterrorism operations) are "lesser included" cases. In other words, the forces necessary to support the primary mission areas should be sufficient to support all of the secondary mission areas, assuming the United States is not engaged in a conflict with a great power adversary. However, the study notes that there could be exceptions to this for some specialized forces, such as special operations aircraft needed for counterterrorism operations.[43]

36. Ibid., 58.
37. Ibid., 59.
38. Ibid., 62.
39. Ibid., 59-60.
40. Ibid., 60.
41. Ibid., 60-61.
42. Ibid., 64.
43. Ibid., 57.

KEY MISSIONS AND CAPABILITIES

The Air Force made a key choice in its analysis not to consider new solutions or advanced capabilities beyond what is already in the program of record.[44] As a consequence of this, the Air Force analysis is limited to incremental changes to the status quo rather than fundamental changes in capabilities, forces, and operational concepts. For example, in its unclassified report, the Air Force does not consider the addition of stealthy remotely piloted aircraft for ISR and strike in highly contested environments or the employment of new sensors and munitions on existing aircraft. The MITRE and CSBA studies did not have the same limitations and therefore consider a wider range of force structure options than the Air Force considered.

The CSBA study divides the key missions and capabilities of the Air Force into three main categories. The first category is counterair operations, which is defined to include "defensive and offensive operations in all domains to obtain and maintain a desired degree of air superiority."[45] To enable effective counterair operations in the future, CSBA concludes that the future force structure should include new offensive counterair capabilities that can "operate over long ranges and in highly contested environments, carry a large number of direct attack and standoff munitions, and have a sensor suite that provides a fused, multi-domain operational picture of the battlespace."[46] To this end, it explores new concepts for crewed and remotely operated aircraft teaming and using standoff platforms with long-range air-to-air missiles. It also determines that new missile defense capabilities are needed to help protect U.S. and allied air bases, including "left of launch" and boost-phase intercept systems.[47]

The second category of key missions and capabilities the CSBA study assessed is global strike, which is the ability to attack over long ranges with precision. The study finds that in a Baltic scenario, Russian surface-to-surface missile forces would force U.S. short-range fighters to disperse to smaller air bases and long-range bombers and tankers would need to operate from bases at greater distances.[48] In a South China Sea scenario, the study finds that U.S. strike aircraft would need to operate from Australia, Diego Garcia, the Marianas, and the United States.[49] As a result, the Air Force will need more long-range, penetrating aircraft with "increased speed of action" to close the kill chain in future operating environments. One of the main conclusions of this analysis is that the Air Force should shift from a platform-centric to a payload-centric approach that includes "future standoff and penetrating PGMs [precision-guided munitions], sensors, datalinks, and other mission systems" that are capable of operating in contested areas.[50] It also finds that non-penetrating (i.e., non-stealthy) bombers, fighters, and RPAs can be effectively used for standoff operations in both the Russia and China scenarios, and RPAs in particular can be important force multipliers to "help fill the gap created by attacks on U.S. space-based sensor networks."[51]

44. U.S. Air Force, Fiscal Year 2018 National Defense Authorization Act (NDAA) Section 1064 Study, 3.

45. Gunzinger et al., An Air Force for an Era of Great Power Competition, 69.

46. Ibid., 89.

47. Ibid.

48. Ibid., 92.

49. Ibid., 97.

50. Ibid., 109.

51. Ibid., 108.

The third category in the CSBA study is a catch-all of battle management command and control (BMC2), ISR, airlift, aerial refueling, homeland defense, and nuclear deterrence. The report notes that both China and Russia recognize the vital role BMC2, ISR, and aerial refueling aircraft play for U.S. power projection capabilities, especially for a scenario like the South China Sea with large-scale, dispersed operations over long distances.[52] Many of these aircraft types are few in number, making them attractive targets for a disabling attack by an adversary seeking to limit or complicate U.S. involvement in a conflict. The threats posed to these types of aircraft include long-range air-to-air missiles, electronic attacks that can blind or confuse sensors, and cyberattacks that can cripple communication networks. Rather than having small numbers of high-value assets for BMC2 and ISR, the CSBA study recommends transitioning to a more resilient and distributed architecture that uses stealthy, long-loiter RPAs to penetrate adversary air defenses and provide persistent ISR coverage to supplement the sensor data provided by other penetrating aircraft.[53] The study does not examine in detail how new space-based systems can be used to augment or replace aircraft for BMC2 and ISR missions.

It also finds that the tanker fleet is too small to support the range and scale of operations required in the scenarios posited, and it recommends a new tanker design be procured after the KC-46A that could be remotely operated, smaller, and more survivable for distributed operations on the edges of adversary air defenses.[54] The study notes that the use of fifth generation fighters for the homeland defense mission makes these aircraft less ready and available for a Baltic or South China Sea scenario and instead recommends that an RPA or a modified trainer aircraft be adapted for this mission.[55]

The MITRE study also recommends several changes in capabilities for the Air Force's future fleet. It recommends the addition of four bases in the Indo-Pacific region specifically for bombers and tankers and that the Air Force procure large inventories of long-range, penetrating standoff weapons to mitigate the current shortage of bombers capable of penetrating advanced IADS.[56,57] Given the likely routes and basing locations of tankers, the study recommends that these aircraft be used for other roles as well, such as distributed communications and datalink relays, which could reduce the need for other special purpose aircraft.[58]

Like the CSBA study, the MITRE study recommends changes in the capabilities of aircraft used for the homeland defense mission. Noting the costs of operating fourth generation and fifth generation fighters for homeland defense, it recommends using a modified trainer aircraft (F/T-X) as a lower cost alternative. It also recommends procuring the next generation F-15EX to replace the current fleet of F-15C/Ds and eventually the F-15Es once they reach the end of their projected service life.

The MITRE study identifies a key tradeoff in its analysis among basing, capabilities, and inventory: that the "capabilities and numbers of aircraft that are able to operate from more distant bases drive

52. Ibid., 111.
53. Ibid., 118-119.
54. Ibid., 120-124.
55. Ibid., 128.
56. MITRE Corporation, *U.S. Air Force Aircraft Inventory Study Executive Summary*, 7.
57. Ibid., 8.
58. Ibid., 9.

the achievable operational tempo."[59] While longer-range aircraft can be based farther from threats, making them more survivable on the ground, it comes at the expense of OPTEMPO. The study also notes that the low mission capable rate of many Air Force aircraft is effectively a cut in the inventory. For example, of the 157 bombers currently in the inventory, fewer than 100 are mission capable at any moment.[60]

FORCE SIZE AND MIX

Table 1 summarizes the proposed changes each study recommends for the Air Force's future force structure. The CSBA report provides detailed tables on the types of aircraft, the current inventory, the current projected inventory for 2030, and its recommended inventory for 2030. The MITRE unclassified report does not provide a summary table, but the recommendations provide sufficient information to construct an equivalent table for comparison. Where the MITRE study does not specifically note a change to the current program of record, this comparison assumes that MITRE recommends that no change be made.

The Air Force's unclassified report does not provide a breakdown of force structure by aircraft type and numbers of aircraft, as required by the legislation authorizing the study.[61] Instead, it provides the number of squadrons (rather than the number of aircraft) by category of aircraft (rather than type of aircraft). Moreover, the unclassified report does not include the average number of aircraft per squadron used in the analysis, but it notes that most increases in inventory numbers align with the increases in squadrons.[62] For the purposes of comparing to the other studies, this analysis converts the Air Force's number of squadrons to an approximate total aircraft inventory using an average number of aircraft per squadron based roughly on the current force structure.[63]

All three of the studies analyze a combined active, guard, and reserve fleet of Air Force aircraft. They do not explore significant alterations to the current mix of active and reserve component forces, and this was not mandated in the legislation authorizing the studies. The Air Force study was the most explicit about this, noting that it "assumed the Active, Reserve, and Guard component ratios would remain the same."

59. Ibid., 5.

60. Ibid., 7.

61. National Defense Authorization Act for Fiscal Year 2018.

62. U.S. Air Force, *Fiscal Year 2018 National Defense Authorization Act (NDAA) Section 1064 Study*, 5.

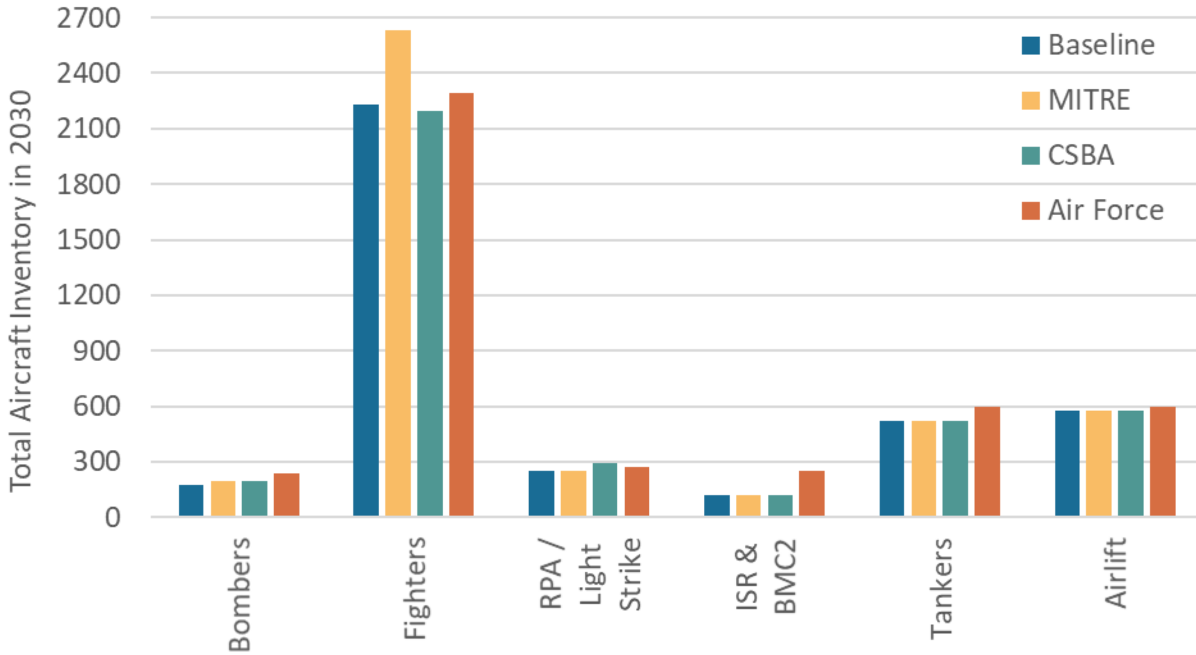
63. To convert the Air Force squadrons to TAI this analysis uses an average TAI per squadron (based on existing force structure) of 17 for bombers, 37 for fighters, 10 for RPA/light strike, 4 for ISR/BMC2, 11 for tankers, 11 for airlift, and 14 for rotary wing.

Table 1: Comparison of Force Structure Recommendations

Aircraft Type	Baseline for FY19	Baseline for FY30	MITRE FY30	CSBA FY30	Air Force FY30
B-1B	62	42	62	42	
B-2	20	20	20	20	
B-21	0	38	38	55	
B-52H	75	75	75	75	
Subtotal Bombers	***157***	***175***	***195***	***192***	***238***
A-10	281	208	208	208	
F-15C/D	234	0	0	0	
F-15EX	0	234	234	0	
F-15E	218	218	218	218	
F-16	935	625	625	625	
F-22A	186	186	186	186	
F-35A	171	762	762	911	
F/T-X	0	0	400	0	
PCA / P-EA	0	0	0	50	
Subtotal Fighters	***2025***	***2233***	***2633***	***2198***	***2294***
MQ-9	252	252	252	252	
MQ-X	0	0	0	40	
Subtotal RPA/Light Strike	***252***	***252***	***252***	***292***	***270***
RQ-4	34	34	34	34	
RC-135	22	22	22	22	
U-2	30	30	30	30	
E-3	31	31	31	31	
E-8	16	0	0	0	
Subtotal ISR & BMC2	***133***	***117***	***117***	***117***	***248***
KC-10	59	0	0	0	
KC-135	398	341	311	341	
KC-46A	-	179	209	179	
Subtotal Tankers	***457***	***520***	***520***	***520***	***594***
C-17	222	222	222	222	
C-5M	52	52	52	52	
C-130J	127	127	127	127	
C-130H	173	173	173	173	
Subtotal Airlift	***574***	***574***	***574***	***574***	***594***

Note: The FY 2019 and FY 2030 baselines are from the CSBA analysis.

Figure 19: Comparison of Force Structure Recommendations for 2030



Bombers: Each of the studies recommends an increase in the overall bomber force from the current program of record projected in 2030. The Air Force recommends growing from 9 to 14 squadrons, noting that it "requires a larger proportional increase for bombers and other longer range capabilities."[64] It does not offer specifics on how it plans to grow to that size, whether by maintaining legacy bombers longer than currently planned or accelerating the fielding of the new B-21 bomber currently in development. The MITRE study recommends delaying any bomber retirements until at least 50 B-21s are operational, which means the planned retirement of 20 B-1s would not occur before 2030.[65] The CSBA study recommends growing the bomber force by accelerating B-21 production so that 55 are fielded by 2030. It further recommends continuing with plans to gradually retire B-1s and maintaining the B-2 and B-52 fleets at current levels.[66]

Fighters: In all three studies, fighters remain the largest single category of aircraft in the future force structure. The Air Force plan calls for a 13 percent increase in the number of fighters, from 55 to 62 squadrons. The MITRE study calls out some of the weaknesses of fighters relative to the threat environment, namely that: they are fundamentally short-range; their maximum combat mission duration is limited to roughly 10 hours by human factors; and the need to base aircraft out of the range of adversary missile threats may place fighters beyond their useful combat radius.[67] Despite these limitations, the MITRE study proposes the largest fighter fleet of the three studies. It recommends continuing the F-35A program as currently planned, procuring new F-15EXs to replace existing F-15C/Ds and eventually the F-15Es, and continuing with plans to retire the A-10s and

64. U.S. Air Force, *Fiscal Year 2018 National Defense Authorization Act (NDAA) Section 1064 Study*, 5.

65. MITRE Corporation, *U.S. Air Force Aircraft Inventory Study Executive Summary*, 7.

66. Gunzinger et al., *An Air Force for an Era of Great Power Competition*, 139-140.

67. U.S. Air Force, *Fiscal Year 2018 National Defense Authorization Act (NDAA) Section 1064 Study*, 9.

F-16C/Ds as F-35As are delivered.[68] Perhaps the most notable change the MITRE study proposes for the fighter inventory is the addition of 400 F/T-X light fighters—a modified version of the new T-7A trainer—to support the homeland defense mission.[69]

The CSBA study recommends a slight decrease in the overall fighter inventory from what is currently projected for 2030. It recommends retiring the F-15C/Ds and not replacing them with F-15EXs. Instead, it recommends using F-35As to help fill shortfalls in air superiority fighters in the interim while transitioning to a "family of capabilities" for air superiority in highly contested environments. It proposes increasing the rate of F-35A deliveries to 70 per year "as soon as possible," with a total of 149 more F-35As procured by 2030 than called for in the current program of record. It further recommends accelerating the new Penetrating Counter Air/Penetrating Electronic Attack (PCA/P-EA) program to begin fielding operational aircraft in 2024 with a total of 50 aircraft delivered by 2030.[70] Like the MITRE study, the CSBA study recommends the procurement of a light attack aircraft, potentially a modified T-7A, for homeland defense, but it does not recommend a specific number of aircraft or timeframe for procurement, and a light attack aircraft is not included in its force tables.[71]

RPA/Light Strike: The studies provide much less detail on the future of the RPA/Light Strike inventory, which includes the current fleet of MQ-9 Reaper aircraft. The Air Force proposes a slight increase in the overall RPA/Light Strike force structure from 25 to 27 squadrons, but it does not provide any details on the types of aircraft or capabilities in the future fleet.[72] The MITRE study did not recommend any specific changes to the RPA fleet and noted that "the long endurance and operating radius of current UAVs did not pose a basing and survivability problem in the scenarios MITRE examined."[73] The CSBA study recommends maintaining the current fleet of MQ-9s due to their high demand by combatant commanders and potentially modifying some of them with air-to-air weapons to support homeland defense and theater airbase defense missions. It also recommends that the Air Force develop a new multi-mission penetrating RPA for strike, counterair, electronic attack, and other combat missions (MQ-X), with the aircraft entering service in 2026 and a total of 40 delivered by 2030.[74]

ISR and BMC2: All of the studies agree on the importance of ISR and BMC2 aircraft in the future fleet, as well as the high demands being placed on these aircraft today. However, they differ significantly in the proposed size of the future inventory of these aircraft. The Air Force proposes a 55 percent increase, from 40 to 62 squadrons, in these "high demand, low supply assets."[75] The MITRE study does not propose any specific changes to these aircraft, but it finds that "in an A2/AD environment, these aircraft are at peril at increasingly long standoff ranges." It also notes that as many of these aircraft reach the end of their service lives, the Air Force should consider

68. Ibid.

69. Ibid., 10.

70. Gunzinger et al., *An Air Force for an Era of Great Power Competition*, 140-143.

71. Ibid., 144-145.

72. U.S. Air Force, *Fiscal Year 2018 National Defense Authorization Act (NDAA) Section 1064 Study*, 5.

73. MITRE Corporation, *U.S. Air Force Aircraft Inventory Study Executive Summary*, 11.

74. Gunzinger et al., *An Air Force for an Era of Great Power Competition,* 143-144.

75. U.S. Air Force, *Fiscal Year 2018 National Defense Authorization Act (NDAA) Section 1064 Study*, 5.

transitioning to more stealthy, attritable, or space-based platforms in the future, and if aircraft are retained, it should avoid small fleets of single-mission aircraft because they are cost inefficient.[76]

The CSBA study places a high priority on transitioning to a mix of ISR and BMC2 aircraft capable of operating in a contested environment. It recommends maintaining and modernizing the fleet of E-3 Airborne Warning and Control System (AWACS) aircraft through 2030 and retiring the fleet of E-8 Joint Surveillance and Target Attack System (JSTARS) in the mid-2020s, as currently planned. It recommends development of the Advanced Battle Management System (ABMS) that is not a single aircraft type but rather a "multi-domain system-of-systems," although this capability would not begin fielding until after 2030. It also recommends maintaining the RQ-4, U-2, and RC-135 fleets of ISR aircraft at current levels and developing a new persistent, penetrating ISR platform in the future. It notes that penetrating and persistent ISR is needed to interdict "highly mobile armored vehicles and other land forces invading a NATO ally" and to find and track "mobile SAMs, missile launchers, and other high-end threats" in a future highly contested environment.[77]

Tankers: The studies all agree that tankers will be increasingly in high demand due to the future threat environment and the need for aircraft to operate over greater distances. The Air Force study cites a major shortfall in the tanker fleet and recommends increasing the tanker force by 35 percent, from 40 to 54 squadrons, although it does not say what kind of tankers. The MITRE study notes that in an A2/AD environment, tanker fuel offloads are diminished because the tankers themselves burn more fuel when operating from more distant bases, which contributes to higher demand for tankers. It recommends retiring the KC-10 (as currently planned) but delaying these retirements until KC-46A deliveries "normalize." After the initial 179 KC-46As are delivered, the MITRE study recommends continuing to procure 10 per year to accommodate the retirement of additional KC-135s.[78] The CSBA study also recommends delaying the KC-10 retirement by two or more years to ensure sufficient KC-46As have been delivered. But rather than continuing to buy more KC-46As, it recommends developing a new, purpose-built tanker. This future tanker would not be fielded until after 2030 and could be remotely operated, able to operate in a somewhat contested environment and from smaller, dispersed bases.[79]

Airlift: None of the studies recommend significant changes to the airlift fleet, which consists primarily of C-17s, C-5Ms, and C-130s. The Air Force study recommends increasing from 53 to 54 airlift squadrons, while both the CSBA and MITRE studies call for maintaining the existing inventory of aircraft. The CSBA study says that the "strategic airlift force may be the Air Force's healthiest force,"[80] but the MITRE study cautions that the C-17 fleet will require replacement or a service life extension beginning in the mid-2030s.[81]

Rotary Wing, Special Operations Forces (SOF), and Trainers: The studies generally provide less detail on the future inventory of rotary wing, SOF, and training aircraft. The Air Force proposes a

76. MITRE Corporation, *U.S. Air Force Aircraft Inventory Study Executive Summary,* 11.

77. Gunzinger et al., *An Air Force for an Era of Great Power Competition*, 145-147.

78. MITRE Corporation, *U.S. Air Force Aircraft Inventory Study Executive Summary*, 8.

79. Gunzinger et al., *An Air Force for an Era of Great Power Competition*, 147-148.

80. Ibid., 148.

81. MITRE Corporation, *U.S. Air Force Aircraft Inventory Study Executive Summary*, 11.

roughly one-third increase in the number of SOF and Combat Search and Rescue (CSAR) squadrons, and it does not include training squadrons in its proposed force structure. The MITRE study does not include SOF or rotary wing aircraft in its analysis, but it does recommend accelerating the production of the T-7A to replace T-38Cs faster than planned and to prepare for co-production of the F/T-X. It does not recommend replacing the T-1 when it is due for retirement and instead recommends training mobility pilots with the T-6 and T-7A.[82] The CSBA study recommends acquiring the Combat Rescue Helicopter to eventually replace the HH-60G. It also recommends the future acquisition of a CSAR aircraft capable of operating in contested areas and continuing with the currently planned recapitalization and modernization of both SOF and training aircraft.[83]

82. Ibid., 10.

83. Gunzinger et al., *An Air Force for an Era of Great Power Competition*, 149.

03

Conclusions

When Congress mandated three independent studies in the FY 2018 NDAA, the intent was to solicit different perspectives on the future force structure of the Air Force. In many respects that objective was accomplished. The three studies were conducted by separate organizations and personnel using different methodologies and focusing on a diverse set of challenges. Despite these differences, the three studies agree in many areas. The areas of agreement suggest a consensus on the future direction of the Air Force—a notable result in what can often be a set of politically and bureaucratically charged issues. In contrast, where the studies diverge from one another suggests areas in which more analysis is needed. The following sections summarize the major areas of agreement, disagreement, and ambiguity among the studies and the unanswered questions that remain for further analysis.

AREAS OF AGREEMENT

All three studies agree on several overarching themes. First, the studies agree that the renewed focus on great power competition with Russia and China means the future force structure of the Air Force should be rebalanced in favor of more long-range, long-loiter platforms. This includes long-range bombers, long-loiter RPAs, and the tankers, bases, and other enablers that support them.

The studies agree that the increasing threat environment and proliferation of advanced IADS means the future force needs platforms that are more survivable in a highly contested operating environment. An underlying theme in all three studies is that the Air Force of the future should move from single-mission, platform-centric systems toward more multi-mission, payload-centric systems. An example of this is the plan, implicitly or explicitly endorsed by all three studies, to move away from systems like the E-8 JSTARS toward more payload-centric, multi-domain solutions that leverage other existing platforms where possible.

The studies also agree on several specific program decisions. They agree that the two most prominent aircraft acquisition programs—the B-21 and F-35A—should continue as planned or be accelerated. They also agree that the existing fleet of MQ-9s should not be retired, and the CSBA study envisions a modified MQ-9 taking on more missions, such as homeland air defense. Another area of agreement is that no significant changes are needed to the airlift, SOF, or rotary wing fleets.

AREAS OF AMBIGUITY

The three studies are ambiguous on several key issues, due largely to the fact that the MITRE and Air Force unclassified studies lack the same level of detail as the CSBA study. For light attack aircraft in particular, the studies do not explicitly agree or disagree. The Air Force study is essentially silent on the issue because it does not provide enough detail in the unclassified report to know if new light attack aircraft are included in its recommended inventory of fighters. The CSBA study endorses the idea of procuring light attack aircraft as a more cost-effective alternative to using fourth and fifth generation fighters for the missions it would support. And it notes that the T-7A trainer currently being procured could be modified for the light attack role.[84] But unlike other recommendations in the CSBA study, it does include projected numbers of these platforms in its 2030 force structure. The MITRE study provides the clearest endorsement of a light attack aircraft, recommending the procurement of 400 F/T-X aircraft.[85]

Agreement is less ambiguous when it comes to nuclear modernization and the ICBM leg of the triad. The Air Force study explicitly maintains the current number of ICBM squadrons and includes them in its overall tally of 386 squadrons by 2030. The CSBA study endorses ICBM modernization and maintaining the current number of ICBMs, but it does not include them in its force structure tables, which are limited to airborne platforms. In contrast, the MITRE study is silent on ICBMs in its recommendations because it only focuses on aircraft inventories. It does not explicitly endorse ICBM modernization because it was outside the scope of its analysis.

AREAS OF DISAGREEMENT

Several areas stand out as points of contention among the studies. At a high level, one of the main differences in the studies is that they use different force sizing constructs and planning scenarios. While this was not specified by the legislation mandating the studies, one of the implicit reasons for commissioning three independent studies was to solicit independent perspectives on a force sizing construct for the Air Force. The studies use different assumptions about the simultaneity and objectives of scenarios involving near-peer competitors. The Air Force analysis uses planning scenarios derived from the National Defense Strategy, which call for a force capable of defeating aggression by one major power while also deterring aggression from a second major power. The CSBA analysis uses a more stressing standard of being able to conduct decisive operations against two major powers with only 10 to 20 days of separation in conflict initiation. It further assumes that forces engaged in one theater will not be able to swing to the other theater in significant numbers. The MITRE study appears to only use a China scenario as the basis for its analysis, and it implicitly assumes that all other scenarios and missions are lesser included cases. However, the CSBA results show that a Russia scenario and the nuclear deterrent mission each require a significantly different mix of capabilities and capacity than a Pacific scenario. Thus, a China scenario alone may not be the most stressing case for all elements of the force.

The Air Force study differs from the other studies in its adherence to the program of record. It explicitly states that one of the assumptions it makes is that the current program of record "will and can deliver as planned to either fill capacity or capability gaps in the current force."[86] It does not consider "new solutions" or "game changing technologies" as part of its analysis.[87] The CSBA and MITRE studies, in contrast, do not make the same assumption. In particular, the CSBA study recommends fielding some new capabilities not currently in the program of record, such as a new

84. Gunzinger et al., *An Air Force for an Era of Great Power Competition*, 144-145.

85. MITRE Corporation, *U.S. Air Force Aircraft Inventory Study Executive Summary*, 9-10.

86. U.S. Air Force, *Fiscal Year 2018 National Defense Authorization Act (NDAA) Section 1064 Study*, 2.

87. Ibid., 3.

tanker design and a new penetrating RPA for strike and ISR, and the MITRE study recommends fielding a new light attack aircraft.

The studies also disagree on some specific near-term programmatic decisions. The most significant of these is whether to procure new F-15EX fighters to replace the aging F-15C/Ds. The MITRE study recommends procuring the F-15EX to replace the F-15C/Ds and later the F-15Es as well. The CSBA study does not recommend procuring the F-15EX and instead proposes replacing the F-15C/Ds with F-35As in the interim and an unspecified "family of capabilities" for air superiority in the future. While the Air Force study proposes growing the fighter force overall, it is silent on the F-15EX issue—although the FY 2020 budget request that was released at roughly the same time as the Air Force's study includes funding for the F-15EX.

UNANSWERED QUESTIONS

The three studies left some questions unanswered, and in other cases raised new questions that should be addressed in future analysis. A significant issue the studies did not settle is how to make the force of the future affordable and fiscally sustainable. The Air Force study is explicit in saying that it is a "strategy-driven, rather than a budget-constrained, analysis," and it does not provide an estimate for the additional funding required to grow the Air Force as proposed.[88] But a resource-unconstrained analysis that is only driven by strategy or threats naturally leads to a trivial solution: buy more of everything. The *raison d'être* for strategy is to set priorities that determine how finite resources are allocated among competing demands. Without some constraints on the resources available, there would be no need for strategy.[89]

The CSBA and MITRE studies are more nuanced in using budget considerations to inform their strategy-driven approach. For example, the MITRE analysis pays particular attention to ways of reducing operation and sustainment costs in the future force, as the NDAA language explicitly requires, and it estimates that the proposed force structure will require a 10 percent increase in the Air Force's aircraft-related budget between now and 2030.[90] The CSBA study methodology included a budget rebalancing exercise as part of its analysis that had teams of experts build different force structures based on different budget levels, ranging from $4 billion less to $8 billion more in annual funding.[91] One notable result from this exercise is that even the teams that were given budget increases cut the overall inventory of aircraft—in sharp contrast to the CSBA study's ultimate recommendations.[92] This suggests that the exercise participants determined that the Air Force's current force structure requires significant rebalancing, such as cutting legacy systems to free up resources for more advanced capabilities. The inventory levels may have also been lower in the exercise because participants invested in new capabilities that would not be fully fielded by 2030.

All three of the studies fail to address a persistent issue the Air Force faces: determining the right mix of forces among the active, guard, and reserve components. Previous attempts by the Air Force

88. Ibid., 2.

89. See: Bernard Brodie, *Strategy in the Missile Age* (Santa Monica, CA: RAND, January 1959), 358-389, https://www.rand.org/pubs/commercial_books/CB137-1.html.

90. MITRE Corporation, *U.S. Air Force Aircraft Inventory Study Executive Summary*, 5-6.

91. Gunzinger et al., *An Air Force for an Era of Great Power Competition*, 151.

92. Ibid., 156.

to adjust the mix of forces among the components have proven to be highly political and divisive. For example, when the Air Force proposed altering the ratio of active and reserve component aircraft in the FY 2013 budget request, the move prompted protests from members of Congress and resulted in the formation of the National Commission on the Structure of the Air Force to study the issue.[93] Despite the political minefield that this subject can create, additional analysis is needed to examine options for how different types of aircraft and capabilities should be rebalanced among the active, guard, and reserve components.

One of the mandates of the legislation creating the studies was to examine the traditional roles and missions of the Air Force and alternative roles and missions for the future. While the CSBA study provided some discussion of new roles and missions, the Air Force and MITRE studies were silent on this. Future analysis should rethink the roles and missions of the Air Force relative to the other military services, looking for opportunities where the Air Force's latent capabilities and force structure can efficiently and effectively take on additional responsibilities. The time is ripe for a new Key West Agreement that reallocates roles and missions across the services. This is particularly true if a new service, the United States Space Force, is created.

For example, the Air Force could provide greater assistance for roles and missions that belong to the Navy today, such as maritime surveillance, anti-surface warfare, and anti-submarine warfare. Indeed, many of the aircraft the Navy uses for these missions are land-based, fixed-wing aircraft that are either derivatives of commercial aircraft or Air Force-developed aircraft. With modifications, some existing Air Force platforms could be used to perform tasks such as laying sonobouys, providing maritime ISR, and conducting aerial mining. In particular, using Air Force multi-mission RPAs to perform some of these activities could potentially reduce costs significantly compared to using crewed Navy aircraft.

The time is ripe for a new Key West Agreement that reallocates roles and missions across the services.

Another set of unanswered questions that arise from these studies is the future force structure needed for space. The Air Force included space squadrons in its force structure and noted the need for "significant growth in space superiority."[94] It did not, however, address specific types of space capabilities or the capacity of space assets needed. The MITRE and CSBA studies did not include space forces as part of their force structure recommendations. Additional analysis is needed to examine the force structure requirements for space forces in 2030 and beyond. In particular, it should include the following mission areas for space: offensive counterspace; defensive counterspace; space situational awareness and space control; missile warning, tracking, target discrimination, and kill assessment; satellite communications; precision navigation and timing; space-based ISR; weather; and space-based electronic warfare and cyber operations.

The MITRE study raises the issue of the high operation and sustainment (O&S) costs of small fleets of aircraft. Future analysis should examine the Air Force's strategy for small fleets of aircraft and

93. See: Dennis M. McCarthy et al., *National Commission on the Structure of the Air Force* (Washington, DC: National Commission on the Structure of the Air Force, January 2014), https://policy.defense.gov/Portals/11/Documents/hdasa/AFForceStructureCommissionReport01302014.pdf.

94. U.S. Air Force, *Fiscal Year 2018 National Defense Authorization Act (NDAA) Section 1064 Study*, 5.

how it can be better managed in the future. The Air Force currently has more than 30 different types of aircraft with fewer than 50 planes each in the inventory, and 16 of these aircraft types have an inventory of 6 or fewer planes.[95] As the MITRE analysis notes, small fleets generally have much higher operation and sustainment costs per plane because the fixed costs of supporting the fleet (for both maintenance and training) are divided over a smaller number of aircraft. The Air Force should develop a roadmap for how it intends to reduce the number of small fleets in the future, focusing on single-mission aircraft that can be replaced by multi-mission aircraft.

Importantly, this finding in the MITRE report on operation and sustainment costs appears to be in conflict with the Air Force's acquisition strategy for the Next Generation Air Dominance (NGAD) program, which calls for developing small batches of multiple types of aircraft in rapid succession.[96] The "digital century series" approach for the next-generation fighter could leave the Air Force with more costly small fleets of aircraft that exacerbate growth in O&S costs and force difficult tradeoffs between capability and capacity. For example, the relationship between total ownership cost and the number of aircraft in a fleet from Figure 10 suggests that five separate fleets of 72 aircraft each (for a total of 360 aircraft) would cost roughly $6.8 billion annually to operate and sustain (in FY 2020 dollars).[97] In contrast, a fleet of 360 aircraft of one type would cost just $3.0 billion annually. Alternatively, the annual ownership cost of five fleets of 72 aircraft each is roughly the same as the annual ownership cost of one fleet of 1,800 aircraft. While small fleets may be desirable for rapid integration of new technologies into the force and maintaining competition in the industrial base, this approach would likely lead to higher operation and sustainment costs and a smaller force than the Air Force could otherwise afford.

The "digital century series" approach for the next-generation fighter could leave the Air Force with more costly small fleets of aircraft that exacerbate growth in O&S costs and force difficult tradeoffs between capability and capacity.

The increasing threat environment and need to operate over greater ranges cited in all three studies raises questions about the future inventory and capabilities of munitions. Additional analysis should examine in more detail the munitions inventory needed to support the future force structure. It should analyze: the capabilities needed in future munitions (e.g., stealth, speed, and range, among others); the tradeoffs between standoff versus direct attack munitions; the inventory of different types of munitions needed to support the planning scenarios used; and the munitions industrial base needed for steady-state production and surge capacity.

The studies also raise questions about the overall RPA strategy for the Air Force. As shown in Chapter 2 of this report, the Air Force's experience so far in using RPAs for the ISR and light strike

95. As of FY 2016, the Air Force's small fleets include aircraft such as the OC-135 (2), E-11 (3), MC-12 (4), C-20 (5), C-32 (6), C-40 (11), and C-37 (12), among others.

96. Valerie Insinna, "The US Air Force's Radical Plan for a Future Fighter Could Field a Jet in 5 Years," Defense News, September 16, 2019, https://www.defensenews.com/digital-show-dailies/2019/09/16/the-us-air-forces-radical-plan-for-a-future-fighter-could-field-a-jet-in-5-years/.

97. The relationship between total ownership cost (TOC) and total active inventory (TAI) derived from Figure 10 is: $TOC = \$160{,}000{,}000 * TAI^{0.5}$. The steady-state annual TOC used here does not include the initial development and procurement costs of the aircraft and is in FY 2020 dollars.

mission areas in a permissive threat environment indicates RPAs can have much lower operation and sustainment costs and higher mission capable rates than crewed aircraft. A separate more detailed analysis should explore new missions for RPAs and the operational advantages and disadvantages of using RPAs for different missions. For example, the Air Force and DARPA have explored the use of low-cost and potentially expendable RPAs for swarming operations and as scouts for crewed aircraft. A long-term strategy is needed for how these aircraft will be integrated into the force structure to potentially complement or supplement the need for larger crewed aircraft. The RPA strategy should also explore the lessons learned from RPAs that can help reduce operation and sustainment costs and improve fleet readiness for the Air Force overall.

All three studies recommend an overall increase in the force structure of the Air Force. Such an increase will require more personnel in a variety of areas, particularly maintainers and pilots. The Air Force already has a shortage of personnel in key areas, and a significant increase in force structure could exacerbate these personnel shortages, resulting in a "hollow force."[98] Any plans to significantly increase the number of aircraft in the inventory will require a coordinated effort to increase the number of personnel and expand the training pipeline to support these aircraft. Given the difficulty the Air Force has had in addressing its current pilot shortage, the ability to recruit, train, and retain qualified personnel may be the ultimate limiting factor in the Air Force's ability to grow.

Another aspect of the future force structure not addressed by any of the studies is the role of commercial services and leased aircraft to augment the Air Force's organic fleet of aircraft. Contractor-owned/government-operated (COGO) and contractor-owned/contractor-operated (COCO) aircraft are already used extensively for airlift, ISR, and training. For example, the Commercial Reserve Air Fleet (CRAF) is relied upon for supplemental airlift capacity in the event of a crisis, and COCO aircraft are used routinely for airlift services. The Air Force is also beginning to use leased aircraft and services for aerial refueling, training, and special purpose ISR missions. Leasing aircraft and procuring aircraft services can help fill capacity shortfalls due to the inherent bumps and irregularities in demand for certain capabilities. For example, in recent years the Air Force has experienced surges in demand for trainers, tactical airlift, aerial refueling, and ISR. The Air Force needs a comprehensive analysis and overarching strategy for aircraft leasing and services to augment its force structure plans.

FINAL THOUGHTS

As noted in the Air Force study, the future force structure of the Air Force is more than just a number. For years, the Navy has focused on ship count as its metric for force structure, most recently calling for a 350-ship fleet. While it is tempting for the Air Force to also find a unidimensional metric—a single number—to rally around, the future threat environment is increasingly complex, and the capabilities needed to meet these threats and execute the National Defense Strategy are multidimensional. The force of the future does not lend itself to a point solution, such as a static target for the number of squadrons or the number of aircraft in the inventory. Instead, what is needed is a rebalancing plan throughout the 2020s that adjusts dynamically as the resources available change, new threats emerge, and new capabilities come online. As the CSBA rebalancing

98. Andrew Feickert and Stephen Daggett, "A Historical Perspective on 'Hollow Forces,'" Congressional Research Service, 8-9, https://fas.org/sgp/crs/natsec/R42334.pdf.

exercise showed, a smaller rebalanced force that focuses more on long-range, long-loiter, and increasingly autonomous and remotely operated capabilities may be more desirable than the current program of record. Such a rebalancing, however, will require difficult tradeoffs. For the U.S. Air Force to maintain its supremacy in the skies, it must stay focused on the future and not cling to the traditions, aircraft, and operational concepts of the past. As Billy Mitchell wrote nearly a century ago, "In the development of air power, one has to look ahead and not backward and figure out what is going to happen, not too much what has happened."[99]

99. William "Billy" Mitchell, *Winged Defense: The Development and Possibilities of Modern Air Power: Economic and Military* (New York: G. P. Putnam's Sons, Press, 1925), 20-21.

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The NASA Langley Research Center in Virginia provides shelter for F-22 Raptors from Joint Base Langley-Eustis, Va.

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