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## AUTHORS

Rhys McCormick  
Gregory Sanders  
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A Report of the CSIS DEFENSE-INDUSTRIAL INITIATIVES GROUP

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Center for Strategic & International Studies  
1616 Rhode Island Avenue, NW  
Washington, DC 20036  
202-887-0200 | [www.csis.org](http://www.csis.org)

# Abstract

The Army has a pioneering acquisition strategy to develop, procure, and field FARA and FLRAA in accelerated timelines under its Future Vertical Lift (FVL) effort, one of the service's top modernization priorities. This report characterizes and assesses the Army's approach to vertical lift modernization; identifies long-term issues relating to programmatic, sustainment, and portfolio costs; and clarifies the long-term affordability implications of the Army's portfolio approach to vertical lift modernization. CSIS's preliminary analysis found that both programs can be accommodated at historically viable levels of modernization funding, but the Army will need to manage cost risk through the prototyping efforts, particularly with respect to operating and support costs.

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# Introduction

In 2016, the Army faced a difficult truth: “without changes to its modernization strategy, the Army risks losing qualitative tactical overmatch.”<sup>1</sup> At that time, the Army was experiencing a “triple whammy” of significant declines in the Army’s overall modernization budget; a lost procurement decade; and historical declines in research, development, test, and evaluation (RDT&E) budgets. These difficulties were compounded by an Army modernization strategy that was ever-changing and lacking consensus amongst Army leaders about the Army’s top modernization priorities. Given these problems, the Army unveiled a new, more focused modernization strategy in 2017 that was centralized on six modernization priorities:<sup>2</sup>

1. Long-Range Precision Fires
2. Next-Generation Combat Vehicle
3. Future Vertical Lift
4. Network
5. Air and Missile Defense
6. Soldier Lethality

These six priorities were chosen as they best aligned with the then-emerging Multi-Domain Operations (MDO) concept that sought new ways to tackle the operational challenges presented by strategic competitors like China and Russia.<sup>3</sup> Given their sophisticated anti-access area denial (A2/AD) capabilities, the Army’s existing inventory was insufficient. Legacy platforms, like the existing vertical lift fleet, lacked the necessary speed, range, endurance, survivability, or lethality to compete in this A2/AD environment. Instead, MDO, in accordance with the priorities outlined for the Joint Force in the 2018 National Defense Strategy,<sup>4</sup> envisioned a modernized force around three mutually reinforcing core tenants:<sup>5</sup>

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1. Rhys McCormick and Andrew Hunter, *The Army Modernization Imperative: A New Big Five for the Twenty-First Century* (Washington, DC: CSIS, 2017), [https://csis-prod.s3.amazonaws.com/s3fs-public/publication/170530\\_Hunter\\_ArmyModernization\\_Web.pdf?230oluRM4PwJB4XRunDpVRMndOnunc](https://csis-prod.s3.amazonaws.com/s3fs-public/publication/170530_Hunter_ArmyModernization_Web.pdf?230oluRM4PwJB4XRunDpVRMndOnunc).

2. Mark A. Milley and Ryan D. McCarthy, “Modernization Priorities for the United States Army,” Department of the Army, October 3, 2017, <https://admin.govexec.com/media/untitled.pdf>.

3. Stephen Townsend, “Accelerating Multi-Domain Operations: Evolution of An Idea,” The Modern War Institute, July 23, 2018, <https://mwi.usma.edu/accelerating-multi-domain-operations-evolution-idea/>.

4. U.S. Department of Defense, *Summary of the 2018 National Defense Strategy of The United States of America: Sharpening the American Military's Competitive Edge* (Washington, DC: DoD, 2018), <https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf>.

5. U.S. Army Training and Doctrine Command, *The U.S. Army in Multi-Domain Operations in 2028*

1. Calibrated Force Posture: “Position and the ability to maneuver across strategic distances”
2. Multi-Domain Formations: “Capacity, endurance, and capability to access and employ capabilities across all domains to pose multiple and compounding dilemmas on the adversary”
3. Convergence: “The rapid and continuous integration of all domains across time, space, and capabilities to overmatch the enemy”

There is now a consensus amongst policymakers about the importance of Army modernization, but there are significant questions as to whether the Army can afford such an ambitious modernization program.<sup>6</sup> Furthermore, the Army is pioneering an acquisition approach that uses a combination of programmatic approaches, many of which depart from the traditional defense acquisition system, to accelerate its modernization program. These nontraditional approaches have previously been focused on isolated efforts rather than developing and fielding major weapon systems. As a result, oversight and approval authorities in both the Department of Defense (DoD) and Congress are raising questions about the long-term affordability, sustainability, and industry dynamics of the Army's approach. While other modernization programs may be a higher priority or field sooner, the maturity and size of the FVL portfolio offer an early opportunity to characterize and assess the Army's modernization approach. This report begins by assessing the current state of the Army's vertical lift portfolio and its FVL plans. Next, it assesses the long-term affordability of the Army's approach by analyzing budget data and various cost-scenarios that might drive up program costs. Finally, it looks at the previous lessons learned in acquisition that the Army can apply to manage long-term program risk.

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(Newport News, VA: U.S. Army Training and Doctrine Command, 2018), [https://www.tradoc.army.mil/Portals/14/Documents/MDO/TP525-3-1\\_30Nov2018.pdf](https://www.tradoc.army.mil/Portals/14/Documents/MDO/TP525-3-1_30Nov2018.pdf).

6. Jen Judson, “Will the US Army have enough to pay for its modernization?” *Defense News*, September 18, 2019, <https://www.defensenews.com/land/2019/09/18/will-the-army-have-enough-to-pay-for-its-modernization/>.

## What Is Future Vertical Lift?

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**FVL is not a single platform**, but a family of systems and enablers designed to replace the existing vertical lift fleet and restore tactical overmatch against near-peer competitors. There are long-term plans for FVL to comprise five unique capability sets encompassing the entire rotorcraft spectrum, from light scout to heavy lift, but the Army's current efforts are focused on the light-scout Future Attack Reconnaissance Aircraft (FARA) and medium-lift Future Long-Range Assault Aircraft (FLRAA). In addition to FARA and FLRAA, the Army currently has two other lines of efforts underway as part of the FVL program, the Future Unmanned Aircraft System (FUAS), and the FVL Modular Open System Architecture (MOSA). FUAS and MOSA are not rotorcraft, but critical enablers shared across the entire FVL family of systems. FUAS, working in coordination with FARA and FLRAA and the existing fleet, enables long-range precision fires by combining ground-launched UAS with air-launched effects (ALE). Finally, MOSA is the set of common design standards that will be applied across the entire FVL fleet, enabling faster technological insertion, greater competition, and interoperability across the FVL fleet.



## What Is FVL Replacing?

FVL is replacing an operational fleet comprised primarily of the UH-60 Black Hawk; AH-64 Apache attack helicopters; CH-47 Chinook heavy-lift helicopter; and the UH-72 Lakota light utility helicopters.<sup>7</sup> FLRAA (capability set three) will replace the UH-60 Black Hawk. FARA (capability set one) will take over the scouting mission from the AH-64 Apache. Although FARA is replacing the Apache in the scouting mission, it is not an Apache replacement program. Instead, FARA fills a long-term capability gap that was deepened when the Army decided to retire the OH-58 Kiowa Warrior due to budgetary cuts.<sup>8</sup> Finally, while there are no immediate plans to replace the AH-64 Apache and CH-47 Chinook as part of the FVL effort, the Army has indicated that those could be follow-on programs—roughly aligning with capability set two and capability set five, respectively—once FARA and FLRAA are further along.

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7. The Army's complete rotary-wing inventory also includes approximately 53 MH-6M Little Birds used by the special operations community, and the TH-67 Creek used for training.

8. Sydney J. Freedberg, "Don't Panic About Apaches: Army Not Junking Gunships," *Breaking Defense*, March 28, 2019, <https://breakingdefense.com/2019/03/dont-panic-about-apaches-army-not-junking-gunships/>.

# What Is the Army's FVL Acquisition Approach?

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**Under the Army's new Big Six** modernization strategy, accelerating the delivery of FARA and FLRAA has become the critical driver of both programs. In order to move forward the schedule of these programs, the Army is pioneering the use of a combination of acquisition approaches that depart from the traditional DoD Instruction 5000.02 defense acquisition system. Through a combination of 10 U.S. Code § 2371b (commonly known as Other Transaction Authority, or OTA) and the Fiscal Year 2016 National Defense Authorization Act (NDAA) Section 804 "Middle Tier of Acquisition For Rapid Prototyping And Rapid Fielding" authorities,<sup>9</sup> the Army has been successful in getting companies on contract to begin developing prototypes in less than a year, whereas it might have taken three to five years using the traditional acquisition process.<sup>10</sup> Furthermore, the Army's decision to create Army Futures Command and cross-functional teams (CFT) for its different modernization priorities is working to coordinate the FVL requirements generation process to leverage the learning occurring in these early design efforts. The FVL CFT and the Capability Development Integration Directorate (CDID) out of Army Futures Command are shaping the FARA and FLRAA requirements to restrict the number of mandatory

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9. Authority of the Department of Defense to carry out certain prototype projects, 10 U.S. Code (2015) § 2371b., <https://www.law.cornell.edu/uscode/text/10/2371b>; "Acquisition Process: Middle Tier Acquisition (Section 804," Acqnotes.com, <http://acqnotes.com/acqnote/acquisitions/middle-tier-acquisitions>.

10. Jen Judson, "US Army picks 5 teams to design new attack recon helicopter," *Defense News*, April 23, 2019, <https://www.defensenews.com/digital-show-dailies/aaaa/2019/04/23/us-army-picks-5-teams-to-design-new-us-army-attack-recon-helicopter/>.

Key Systems Attributes (KSA) to only the vital characteristics and leave the remaining desirable characteristics as the trade-space for down-select competitions. This in turn accelerates the acquisition process by limiting the number of mandatory requirements that can slow down programs and enables companies to innovate within the trade space.

“Accelerating the delivery of FARA and FLRAA has become the critical driver of both programs.

### Future Attack Reconnaissance Aircraft: Acquisition Approach

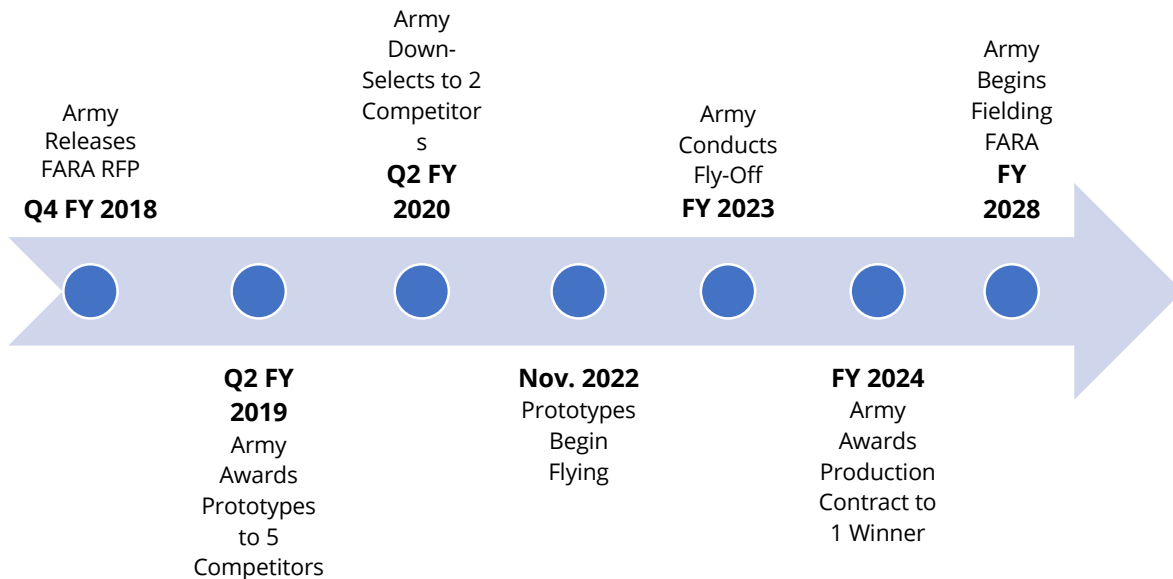
Although the original FVL plans called for procuring and fielding the capability set three (medium-lift helicopter) first,

the Army's urgent scout capability gap led the Army to accelerate the initiation of FARA, a capability set one-equivalent aircraft, from the 2030s to FY 2028. To meet this accelerated delivery, the Army has signaled that it intended to heavily leverage its new OTA authorities to conduct prototyping and follow-on production awards. In the initial request for proposal (RFP) released in June/September 2018, the Army announced it intended to make initial awards to four to six companies in order to build FARA prototypes. And on April 23, 2019, the Army announced that it had made awards to five companies: AVX Aircraft partnering with L-3 Communications, Bell Helicopter, Boeing, Karem Aircraft, and Sikorsky.<sup>11</sup> Going forward, the Army intends to down-select to two competitors in the second quarter of FY 2020 who will then compete in a final fly-off competition for the production award contract. Figure 1 below shows the planned FARA program timeline from when the RFP was released to when fielding is planned to begin in FY 2028.

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11. Jen Judson, "US Army aims to get attack recon helicopter prototype flying by 2023," *Defense News*, June 22, 2018, <https://www.defensenews.com/land/2018/06/22/us-army-shoots-to-get-future-attack-recon-helicopter-prototype-flying-by-2023/>.

Figure 1: FARA Program Timeline



Source: "Future Attack Reconnaissance Aircraft Competitive Prototype (FARA CP); Solicitation Number: W911W6-18-R-FVL\_FARACP," Federal Business Opportunities.

#### FUTURE LONG-RANGE ASSAULT AIRCRAFT: ACQUISITION APPROACH

While FARA is now planned to be procured and fielded two years prior to FLRAA, the FLRAA program is currently a more mature design due to the lessons learned from the ongoing Joint Multi-Role Technology Demonstrator (JMR-TD) program. The JMR-TD is an ongoing technology demonstration program that has been prototyping and experimenting with the technologies underlying both the FVL air vehicle and mission systems architecture since 2011. As of March 2019, both of the companies selected to proceed to flight testing, Bell and Sikorsky-Boeing, have started flying their offerings, the V-280 Valor and SB-1 Defiant, respectively.<sup>12</sup> In addition, JMR-TD has funded several companies to prototype and test their mission systems architecture offerings.<sup>13</sup> Although the JMR-TD offerings will not precede directly to the FLRAA competition, they provide critical insights to the Army in the requirements generation process and to the companies competing.<sup>14</sup>

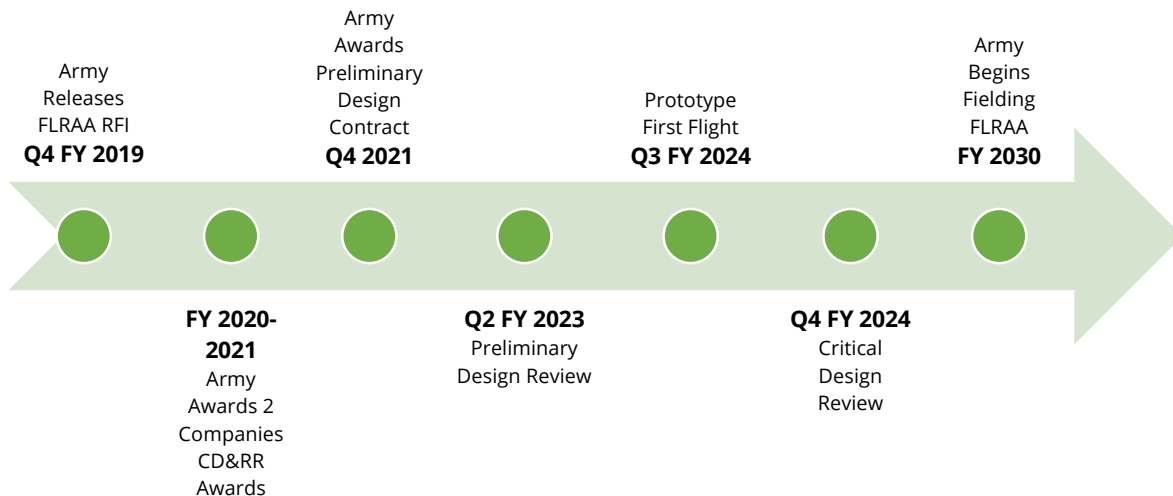
12. Jen Judson, "WATCH: Sikorsky-Boeing Defiant helo takes first flight," *Defense News*, March 21, 2019, <https://www.defensenews.com/land/2019/03/21/sikorsky-boeing-defiant-helo-takes-first-flight/>.

13. "AMRDEC announces Technology Investment Agreements for Future Vertical Lift Aircraft Architecture," U.S. Army, August 15, 2016, [https://www.army.mil/article/173389/amrdec\\_announces\\_technology\\_investment\\_agreements\\_for\\_future\\_vertical\\_lift\\_aircraft\\_architecture](https://www.army.mil/article/173389/amrdec_announces_technology_investment_agreements_for_future_vertical_lift_aircraft_architecture).

14. Ibid.

In April 2019, the Army, Marine Corps, and U.S. Special Operations Command (SOCOM) jointly released a request for information (RFI) on FLRAA to industry. Although not a formal RFP soliciting offers, this RFI outlined the critical performance metrics the Army, Marine Corps, and SOCOM are looking for. Of note, while the Army, Marine Corps, and SOCOM jointly released the FLRAA RFI, each has its own performance metrics.<sup>15</sup> Unlike FARA which seeks to leverage new acquisition authorities to significantly accelerate fielding, FLRAA more closely resembles a traditional acquisition program, though the Senate Armed Services Committee has expressed interest in the Army “using a more tailored acquisition approach for the FLRAA program . . . to expedite the program.”<sup>16</sup> Barring any further acceleration of the program, Figure 2 below shows the Army’s next step is awarding two teams competitive demonstration and risk reduction contracts before selecting a single preliminary design award winner in the fourth quarter of FY 2021.

Figure 2: FLRAA Program Timeline



Source: “Future Long-Range Assault Aircraft RFI; Solicitation Number: PANR-SA\_19\_P-011017,” Federal Business Opportunities.

15. Sydney J. Freedberg, “FVL: Army, Marines, SOCOM Release Ambitious Specs For Future Aircraft,” *Breaking Defense*, April 5, 2019, <https://breakingdefense.com/2019/04/fvl-army-marines-socom-release-ambitious-specs-for-future-aircraft/>.  
 16. U.S. Congress, Senate, Committee on Armed Services, *Defense Authorization Act for Fiscal Year 2020: Report (to Accompany S.1790)*, 116th Cong., 1st sess., 2019, S. Rep. 116-48, <https://www.congress.gov/116/crpt/srpt48/CRPT-116srpt48.pdf>; Dan Parsons, “Senate Defense Panel Wants Army Plan to Accelerate Black Hawk Replacement,” *Rotor & Wing International*, June 19, 2019, <https://www.rotorandwing.com/2019/06/19/senate-defense-panel-wants-army-plan-accelerate-black-hawk-replacement/>.



## **FUTURE UNMANNED AIR SYSTEM AND MODULAR OPEN SYSTEM ARCHITECTURE: ACQUISITION APPROACH**

FARA and FLRAA get most of the attention, but FUAS and MOSA are critical enablers to making the FVL program and the MDO CONOP a success. To replace the RQ-7 Shadow UAS, the Army is taking a “buy, try and inform Shadow-replacement strategy.”<sup>17</sup> The Army is currently conducting demonstrations with Martin UAV, Arcturus UAV, Textron Unmanned Systems, and L3 Harris using this buy, try, and inform replacement strategy. In addition to replacing the UAS platform itself, this effort includes testing launching small, swarming drones known as air-launched effects at low-altitudes at the Army’s Yuma Proving Grounds. The goal is that these air-launched effects (ALE) payloads could be incorporated into the Gray Eagles, Apaches, and FARA. The Army is currently testing these low-altitude air-launched effects payloads at thousands of feet but wants to get to as low as 100 feet.<sup>18</sup>

The Army is developing its FVL MOSA through the JMR-TD’s mission systems architecture demonstration effort, which runs through December 2020. This effort has already produced two working demonstrations and there are plans for up to five more demonstrations by the end of 2020.

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17. Frank Colucci, “The Moving Parts of Future Vertical Lift,” *Vertiflite* (September/October 2019), [https://vtol.org/files/dmfile/fvl-vf\\_septoct\\_20191.pdf](https://vtol.org/files/dmfile/fvl-vf_septoct_20191.pdf).

18. Ibid.

## Can the Army Afford FARA and FLRAA?

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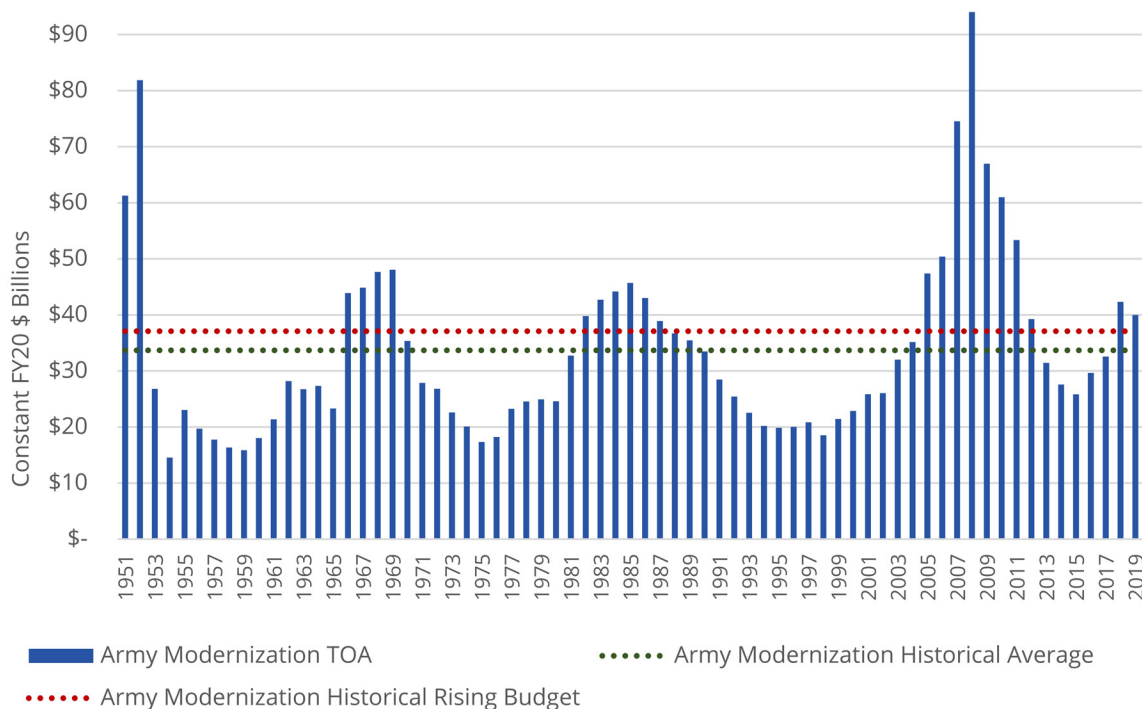
**The Army has a pioneering acquisition strategy** to develop, procure, and field FARA and FLRAA in accelerated timelines, but can it afford to procure both programs while also pursuing its other five modernization priorities? And if the Army can afford to start these programs in the near term, will they remain affordable in the longer term? Although most of the current inventory has been modernized through block upgrades and was either newly acquired or remanufactured in the last 10 years, the current rotorcraft models are starting to hit their technological limitations.<sup>19</sup> Ongoing efforts such as the Improved Turbine Engine Program (ITEP) will help keep the fleet modernized, but the Army may eventually be limited in its ability to upgrade aircraft that were first built in the 1960s (Chinook) and 1970s (Black Hawk and Apache).

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19. Congressional Budget Office, *The Cost of Replacing Today's Army Aviation Fleet* (Washington, DC: Congressional Budget Office, 2019), <https://www.cbo.gov/system/files/2019-05/55180-ArmyAviation.pdf>.

In the following sections, the Center for Strategic and International Studies (CSIS) assesses the long-term affordability of the Army’s FVL portfolio two-fold. First, CSIS looked at the Army modernization budget data—both the historical topline and the Army’s projected spending in the Future Years Defense Program (FYDP) according to the Army FY 2020 Program Objective Memorandum (POM). Second, CSIS developed a vertical lift modernization tool to evaluate how changes at the platform level change the Army’s total FVL portfolio. This vertical lift modernization tool allows CSIS the ability to examine the budget, fleet inventory, and fleet performance implications of alternative scenarios for vertical lift modernization.

Figure 3: Army Modernization Total Obligation Authority, 1951-2019



Source: Department of Defense, *Defense Budget Overview: United States Department of Defense Fiscal Year 2020 Budget Request*, Office of the Under Secretary of Defense (Comptroller/Chief Financial Officer), 2019; CSIS analysis.<sup>20</sup>

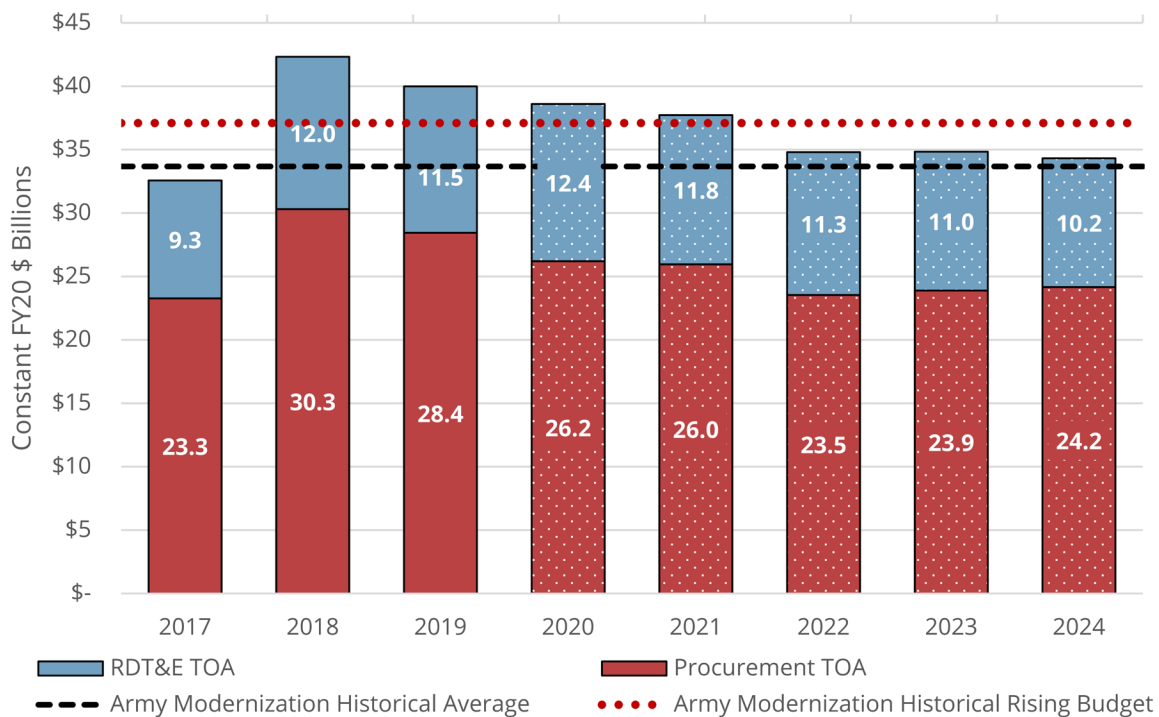
In a previous study of Army modernization, CSIS found that the Army’s modernization budget was highly cyclical with periods of rising budgets during modernization cycles followed soon thereafter by sharp declines.<sup>21</sup>

20. Mine-Resistant Ambush Protected (MRAP) vehicles procurement and other combat tactical vehicles were the largest drivers in the notable increase in Army contract obligations in FY 2008.  
 21. Rhys McCormick, *The Army Modernization Challenge: A Historical Perspective* (Washington, DC: CSIS, 2017), <https://defense360.csis.org/army-modernization-challenge-historical-perspective-2/>.

As shown in Figure 3 above, between FY 1951 and FY 2018, the Army modernization (total research and development [R&D] and procurement) total obligation authority (TOA) averaged \$35.04 billion in FY 2018 dollars but averaged \$38.59 billion during periods of rising budgets, a \$3.55 billion difference. The Army was well below these levels at the time the CSIS study was performed in 2016 but exceeded both in FY 2018 and FY 2019.

Comparing these two historical averages to the Army FY 2020 POM shown in Figure 4 below, Army modernization funding peaked in FY 2018 and is projected to decline over the rest of the FYDP, falling below the average for periods of rising budgets in FY 2022 and falling to the overall historical modernization average in FY 2024. This decline happens at a time when the total DoD budget is projected to flatten after 2020 but largely keep pace with inflation.

Figure 4: Army Modernization in the FY 2020 Budget



Source: Department of Defense, *Defense Budget Overview: United States Department of Defense Fiscal Year 2020 Budget Request*, Office of the Under Secretary of Defense (Comptroller/Chief Financial Officer), 2019; CSIS analysis.

In the FY 2020 request, the Aviation and Ground Maneuver portfolios both accounted for 16 percent—the two largest shares—of the Army’s modernization funding in FY 2020, equating to approximately \$6.2 billion. The Aviation portfolio’s funding was heavily weighted to procurement

(\$4.98B or 19 percent) as opposed to R&D (\$1.12B or 9 percent).<sup>22</sup> If Aviation's share were sustained over the FY 2020 POM, Aviation modernization would shrink to \$5.5 billion in FY 2024 in constant dollar terms, a reduction of approximately 14 percent, but still in-line with Army's average budget for procurement of Army aircraft from FY 2000 to FY 2018.<sup>23</sup>

## Perspectives on FVL Affordability

To assess the long-term affordability of the Army's vertical lift portfolio, CSIS assessed the following scenarios using its vertical lift modernization tool:<sup>24</sup>

- **Baseline Scenario:** What does the Army's vertical lift portfolio look like without FVL?<sup>25</sup>
- **FARA and FLRAA:** What does the Army's vertical lift portfolio look like with both FARA and FLRAA?<sup>26</sup>
- **Operating and Support (O&S) Cost Growth:** What does the Army vertical lift portfolio look like with a 25 percent growth in O&S costs in both FARA and FLRAA?<sup>27</sup>

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22. Assistant Secretary of the Army (Financial Management and Comptroller), *FY 2020 President's Budget Highlights* (Washington, D.C.: U.S. Army, 2019), <https://www.asafm.army.mil/Portals/72/Documents/BudgetMaterial/2020/Roll%20Out/Overview%20and%20Highlights/Army%20FY%202020%20Budget%20Highlights.pdf>.

23. Congressional Budget Office, *The Cost of Replacing Today's Army Aviation Fleet*, 2-3.

24. This paper only includes the most pertinent graphs from CSIS analysis of different FVL procurement strategies. CSIS also analyzed scenarios in which the Army procured just FARA or just FLRAA. The complete collection of graphs and scenario analysis can be found online at [github.com/CSISDefense](https://github.com/CSISDefense).

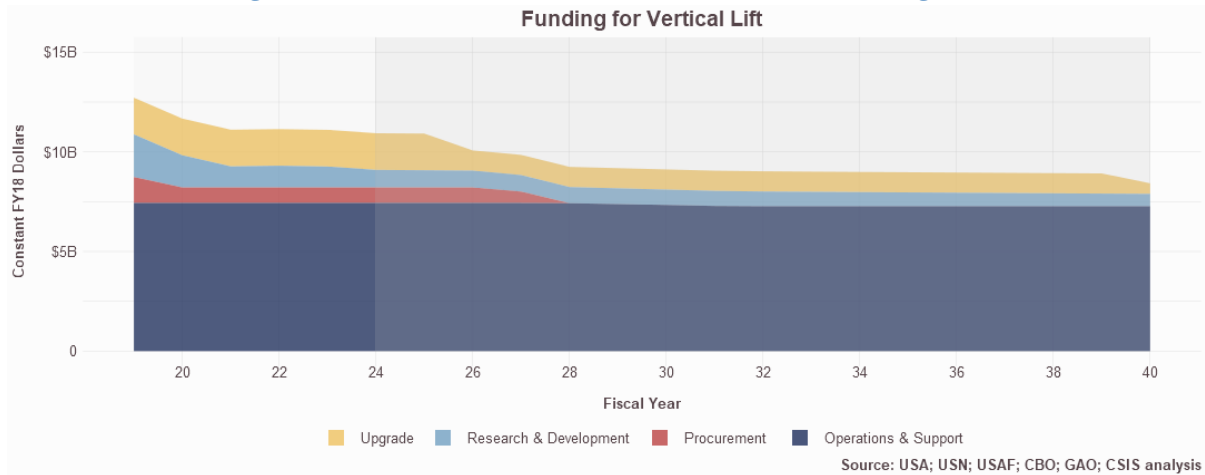
25. The baseline scenario assumes that the Army is not proceeding with the FARA and FLRAA programs. In the absence of FARA and FLRAA, this scenario assumes that the Army continues to remanufacture and procure new models of the UH-60 and AH-64 at the rates detailed in the December 2018 Selected Acquisition Reports. 250 UH-60As and 173 UH-60Ls are retired to reach the Army's 2135 H-60 Black Hawk Army Acquisition Objective (1,375 new 60M and 760 Recapitalized (A/L/V) aircraft. Additionally, as FLRAA is not included in this scenario and SAR data includes new production count but not remanufacture counts, another 657 Blackhawks are upgraded (177 planned in budget + 480 assumed through 2040).

26. The FARA and FLRAA scenario assumes that the Army procures 280 FARA beginning in FY 2024 and reaches full-rate production of 30 per year by FY 2028. In this scenario, AH-64 Apache upgrades cease once FARA reaches full-rate production. Furthermore, this scenario assumes the Army procures 378 FLRAAs beginning in FY 2026 and reaches full-rate production by FY 2029 and does not include funding for any further UH-60 Blackhawk upgrades. In this scenario, UH-60M production ceases when initial FLRAA production starts and begins retiring Blackhawks when FLRAA reaches full-rate production at a one-to-one rate. 250 UH-60As and 173 UH-60Ls are retired to reach the Army's 2135 H-60 Black Hawk Army Acquisition Objective (1,375 new 60M and 760 Recapitalized (A/L/V) aircraft).

27. The O&S Cost Growth uses the same fundamental assumptions as the FARA and FLRAA scenario except for its projected O&S costs. This scenario assumes O&S costs for both FARA and FLRAA are 25 percent higher than what is currently being estimated.



Figure 5: Baseline Scenario: Vertical Lift Funding, 2019-2040



Source: U.S. Army Budget documents; Selected Acquisition Reports; *The Military Balance 2019*; CBO; GAO; CSIS analysis.

Figure 5 above shows the baseline case for the Army's vertical lift fleet (Apache, Lakota, Blackhawk, Chinook) beginning in FY 2019 and running through FY 2040. It includes R&D and procurement funding identified in the POM and Selected Acquisition Reports (with an enduring S&T profile) and depicts O&S cost as a function of the annual O&S cost per aircraft in the inventory. This shows a declining vertical lift modernization funding profile over the POM from \$3.63 billion in FY 2019 to \$2.47 billion in FY 2026 and a slightly rising O&S profile (\$600M in FY 2018 dollars) as aircraft in production enter the inventory, which peaks in FY 2026. This baseline case indicates that if the Army chose to maintain aviation's share of its modernization funding, it could fund additional vertical lift modernization efforts and if it chose to increase its modernization funding and even more so if the Army chose to increase its overall modernization funding to keep pace with inflation.

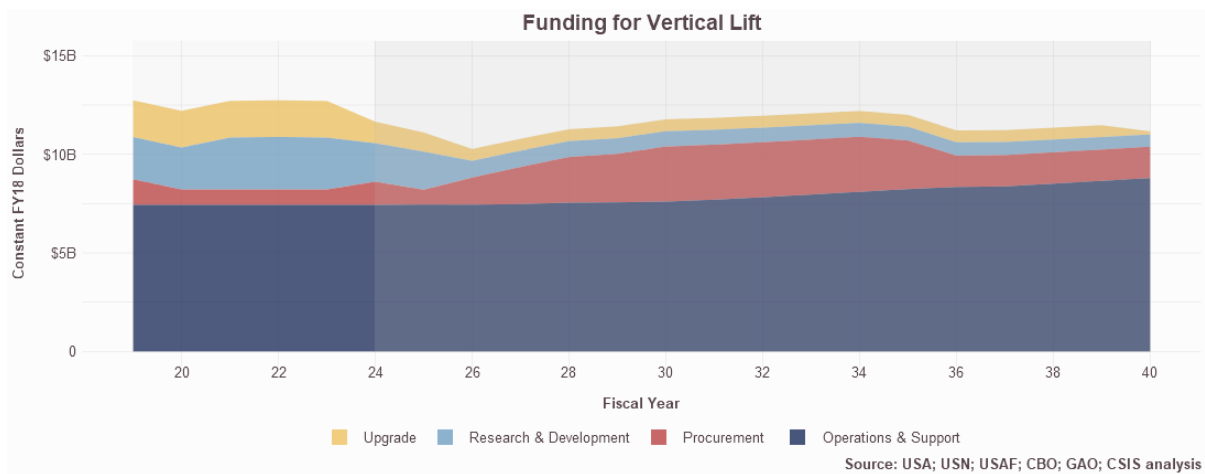
“This baseline case indicates that if the Army chose to maintain aviation's share of its modernization funding, it could fund additional vertical lift modernization efforts..

Figure 6 below shows the funding required for the Army's vertical lift portfolio with both FARA and FLRAA from FY 2019 to FY 2040. The data show that procuring both vertical lift programs at the same time requires investment between FY 2019 and FY 2023 to kick-start those programs while simultaneously upgrading the legacy fleet. After FY 2023, the total funding level required to support both

programs starts to drop for a few years as the legacy program funding drops but before FVL procurement starts ramping up. Procurement funding

starts growing again around FY 2024 and continues rising over the course of the next decade. Finally, O&S costs are projected to rise steadily over the next 20 years. The longer-term increase in O&S costs occurs even though this scenario retires aircraft in the existing inventory on a one-for-one basis as FVL aircraft are procured and is driven by the disparity in projected O&S costs for FLRAA compared to the UH-60 Blackhawk. While the composition of the portfolio shifts across the period in this scenario, it does not meaningfully exceed the current level of funding for the FVL portfolio in constant dollar terms.

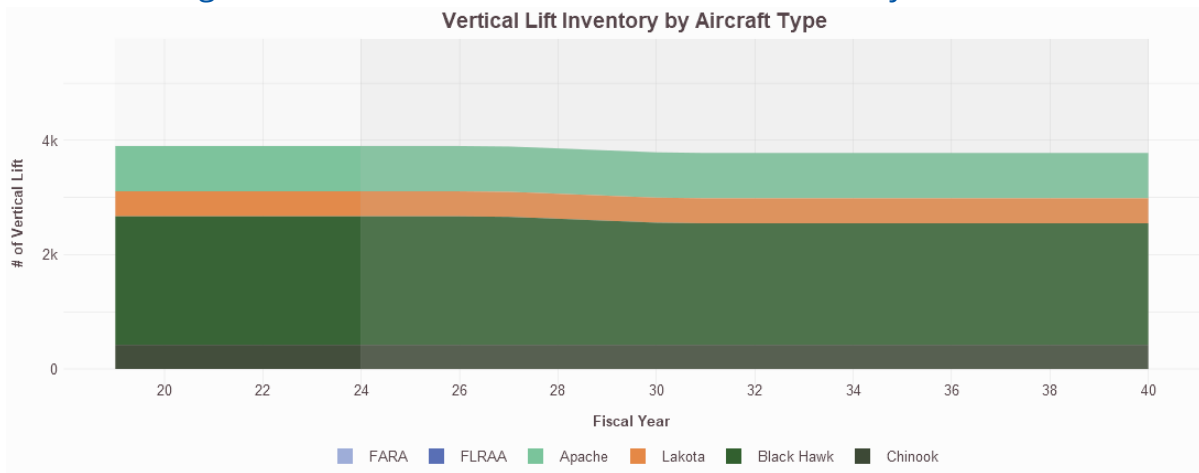
Figure 6: FARA and FLRAA Scenario: Vertical Lift Funding, 2019-2040



Source: U.S. Army Budget documents; Selected Acquisition Reports; *The Military Balance 2019*; CBO; GAO; CSIS analysis.

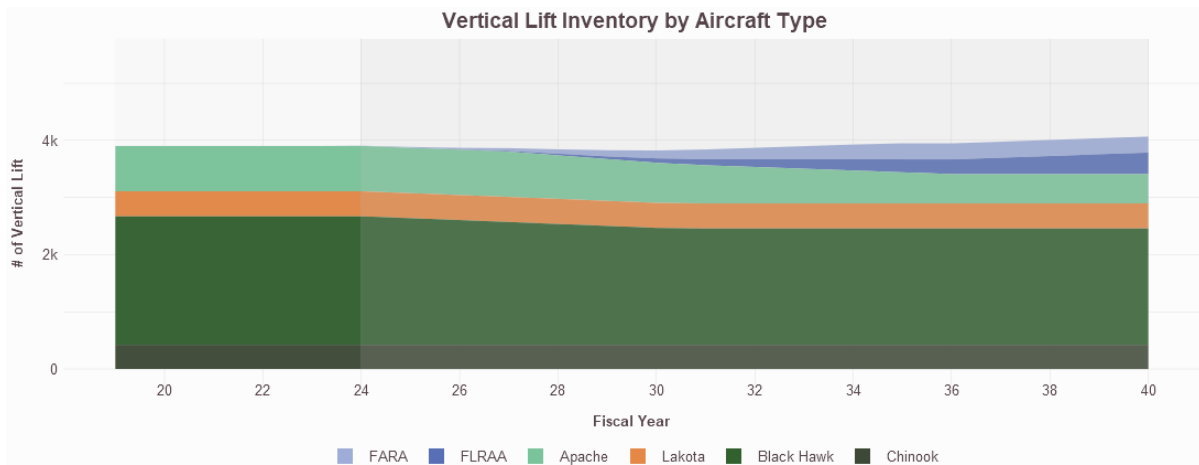
Figures 7 and 8 below show the difference in the composition of the Army's vertical lift portfolio from FY 2019 and FY 2040 between the baseline scenario without FVL and the scenario with both FARA and FLRAA. The FARA and FLRAA additions to the inventory in this scenario are based upon a 30 A/C per year build rate at full-rate production. During the period of analysis, this keeps the Army's inventories relatively stable; however, after 2040, build rates would need to increase to maintain inventory levels, especially for FLRAA.

Figure 7: Baseline Scenario: Vertical Lift Inventory, 2019-2040



Source: U.S. Army Budget documents; Selected Acquisition Reports; *The Military Balance 2019*; CBO; GAO; CSIS analysis.

Figure 8: FARA and FLRAA Scenario: Vertical Lift Inventory, 2019-2040



Source: U.S. Army Budget documents; Selected Acquisition Reports; *The Military Balance 2019*; CBO; GAO; CSIS analysis.

## O&S Cost Scenarios

It is a time-worn truism in discussions of defense programs that although the greatest share of attention is usually given to the development and production of weapon systems, the largest share of their costs comes in the O&S stage of the program lifecycle. In the case of FVL, this observation is likely both true and perhaps uniquely relevant to FVL's long-term success.

The Operating and Support Cost-Estimating Guide published by DoD's Cost Assessment and Program Evaluation (CAPE) office notes that operating and support costs as a percentage of total life cycle cost vary for different kinds

of platforms, constituting a particularly large share for surface ships (69 percent) and a much smaller share for space systems (15 percent).<sup>28</sup> For rotary-wing systems, O&S costs are estimated by CAPE to constitute 68 percent of life cycle costs.<sup>29</sup> Since previous rotary-wing system programs are most closely related to the kinds of systems likely to be acquired for the FARA and FLRAA programs, O&S costs for FVL are likely to be more than 40 times larger than FVL R&D costs and more than two times larger than FVL production costs.

O&S cost estimates are usually developed based on costs experienced with antecedent or reference systems and adjusted according to differences between the antecedent aircraft and the system being estimated.<sup>30</sup> Using data from prior weapon systems to project O&S costs for FARA and FLRAA poses several challenges, however. One of these is that rotary-wing systems are procured and maintained by each of the military services (and also by SOCOM) and the services have different approaches to maintaining these aircraft, leading them to widely varying estimates of the major O&S cost components. A major source of this differentiation is whether aircraft are maintained with two- or three-level maintenance. The Army tends to use two-level maintenance (unit level and depot level) while the Navy and Marine Corps frequently use three-level maintenance, which adds an intermediate level of maintenance between the unit and the depot. The different maintenance concepts alter how costs are allocated between the major O&S cost components and can also affect what is included as O&S cost.

For example, comparing the AH-64E, which is operated by the United States Army, and the AH-1W Super Cobra, which is operated by the United States Marine Corps, shows how these different maintenance concepts influence O&S cost components. The Marine Corps AH-1W allocates a significantly greater share of cost to the maintenance component (39 percent) than to unit-level manpower (30 percent), whereas the Army's AH-64E allocates 43 percent of O&S costs to unit-level manpower and 24 percent to maintenance.<sup>31</sup> These differences can make comparing O&S costs of different aircraft

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28. Office of the Secretary of Defense Cost Assessment and Program Evaluation, *Operating and Support Cost-estimating Guide* (Washington, DC: DoD, 2014), [https://www.cape.osd.mil/files/OS\\_Guide\\_v9\\_March\\_2014.pdf](https://www.cape.osd.mil/files/OS_Guide_v9_March_2014.pdf).

29. Ibid.

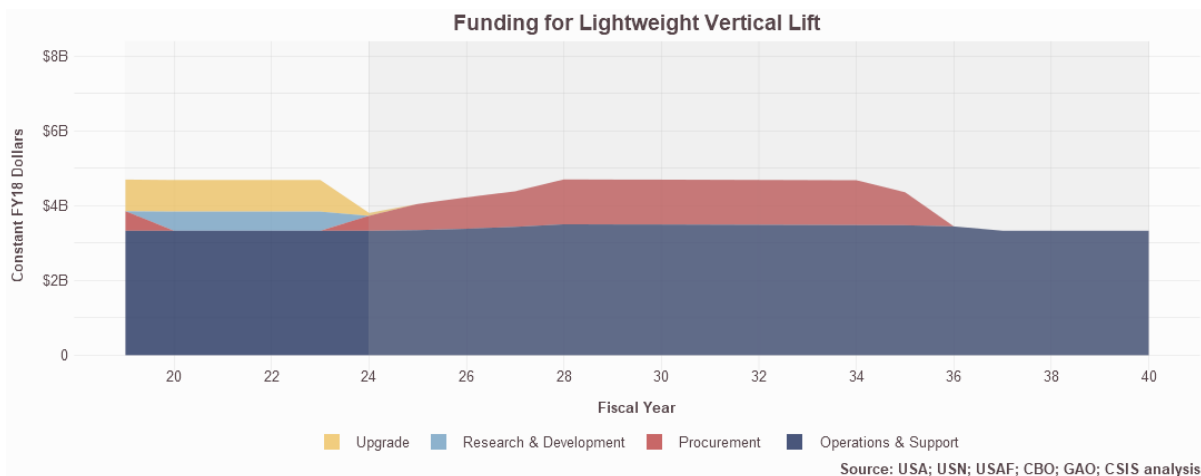
30. Ibid., 5-7.

31. Department of Defense, *H-1 Upgrades (4BW/4BN) (H-1 Upgrades) December 2017 Selected Acquisition Report*, (Washington, D.C.: DoD, 2018), [https://www.esd.whs.mil/Portals/54/Documents/FOID/Reading%20Room/Selected\\_Acquisition\\_Reports/18-F-1016\\_DOC\\_58\\_Navy\\_H-1\\_Upgrades\\_SAR\\_Dec\\_2017.pdf](https://www.esd.whs.mil/Portals/54/Documents/FOID/Reading%20Room/Selected_Acquisition_Reports/18-F-1016_DOC_58_Navy_H-1_Upgrades_SAR_Dec_2017.pdf); Department of Defense, *AH-64E Apache Remanufacture (AH-64E Remanufacture) December 2018 Selected Acquisition Report* (Washington, DC: DoD, 2019), [https://www.esd.whs.mil/Portals/54/Documents/FOID/Reading%20Room/Selected\\_Acquisition\\_Reports/19-F-1098\\_DOC\\_06\\_AH-64E\\_Remanufacture\\_SAR\\_Dec\\_2018.pdf](https://www.esd.whs.mil/Portals/54/Documents/FOID/Reading%20Room/Selected_Acquisition_Reports/19-F-1098_DOC_06_AH-64E_Remanufacture_SAR_Dec_2018.pdf).

challenging because a fair comparison of options requires ensuring that costs are handled in a comparable way. Indeed, the RAND Corporation stressed the importance of normalizing common factors in comparing aircraft O&S costs, including factors such as fuel costs, inflation indexes, how unit personnel are counted and costed, and whether the system has reached steady-state operations in discussing methods for comparing O&S costs.<sup>32</sup> The normalization considerations identified by RAND are in addition to the maintenance approach considerations already discussed.

For FARA, these O&S cost estimation considerations play a relatively minor part in CSIS's affordability analysis. This is because FARA currently has a comparable antecedent system in the AH-64 Apache. While FARA is not a direct replacement for the Apache, FARA and AH-64 are to be operated by the Army. FARA will perform the scouting mission currently being performed in part by Apaches and will likely have a similar maintenance posture to the Apache. For these reasons, CSIS assesses FARA and Apache O&S costs to be comparable both methodologically and in terms of magnitude as a first-order approximation. Figure 9 below shows the funding levels required for FARA, Apache, and Lakota if FARA O&S costs are in line with Apache O&S costs. As the FARA program matures and a production design is selected, significant differences between FARA and the Apache may become apparent, and the affordability analysis will need to be updated accordingly.

Figure 9: Funding for FARA, Apache, and Lakota, 2019-2040



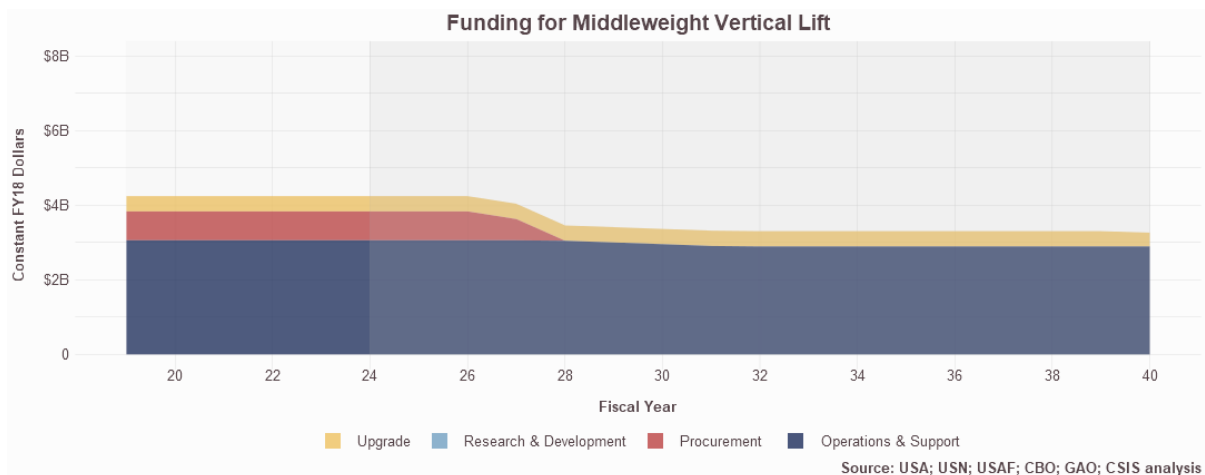
Source: U.S. Army Budget documents; Selected Acquisition Reports; *The Military Balance 2019*; CBO; GAO; CSIS analysis.

32. Michael Boito, Edward G. Keating, John Wallace, Bradley DeBlois, and Ilana Blum, *Metrics to Compare Aircraft Operating and Support Costs in the Department of Defense* (Santa Monica, CA: RAND Corporation, 2015), 22-24.



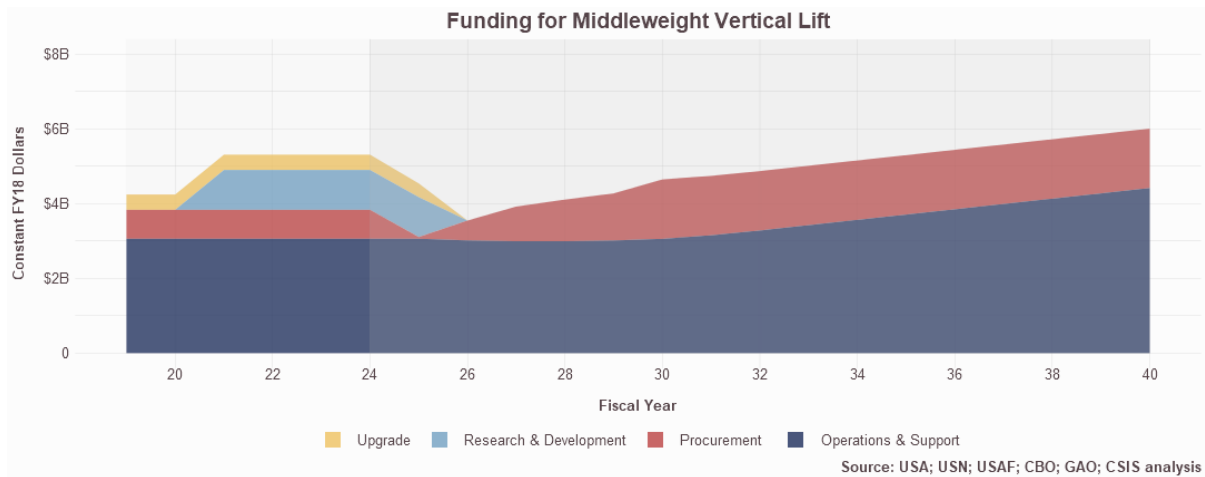
For FLRAA, however, the comparison to currently operating aircraft is more challenging. There are two competitors for the FLRAA program offering different designs. It is not clear that currently operating aircraft are truly comparable, and potential antecedent aircraft are operated by different military services presenting methodological challenges. This means that once a final design is selected, significant analysis will be required to accurately estimate FLRAA's O&S costs. Such detailed cost estimation analysis is beyond the scope of this study. However, for analysis purposes, it is possible to derive a parametric estimate of FLRAA's O&S costs as a percentage of total life cycle cost. Since O&S costs are typically 68 percent of life cycle costs and this study includes early estimates for the R&D and production portions of life cycle costs, an estimate of O&S costs can be derived. CSIS utilized this methodology to develop a parametric estimate of FLRAA's O&S costs—\$4.7 million per aircraft per year—that is used in its vertical lift modernization tool. Figures 10 and 11 below show how O&S costs for the combined Blackhawk and FLRAA fleets stay relatively level through FY 2030 and begin to escalate in the years following. As with FARA, this analysis should be updated once a final design for FLRAA is selected.

Figure 10: Baseline Scenario: FLRAA and Blackhawk Vertical Lift Funding, 2019-2040



Source: U.S. Army Budget documents; Selected Acquisition Reports; *The Military Balance 2019*; CBO; GAO; CSIS analysis.

Figure 11: FLRAA and Blackhawk Funding, 2019-2040



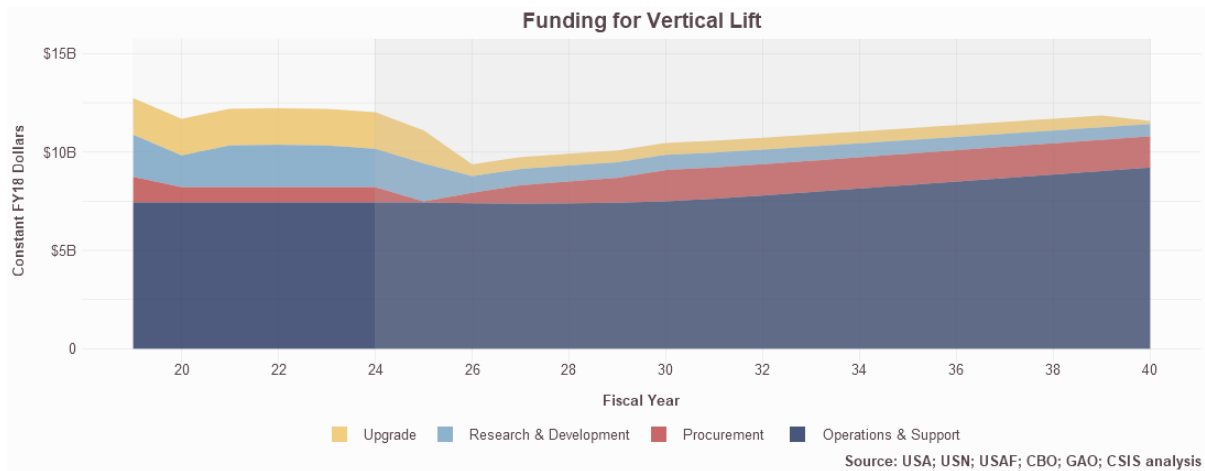
Source: U.S. Army Budget documents; Selected Acquisition Reports; *The Military Balance 2019*; CBO; GAO; CSIS analysis.

The FLRAA case is also different from FARA because FLRAA will be replacing the UH-60 in the Army inventory. Whether or not our parametric estimate of FLRAA's O&S costs proves to be high or low, it will be challenging for the Army to develop a new aircraft that is as inexpensive to operate as the Blackhawk. Hence, the Army's O&S costs for vertical lift will tend to increase as FLRAA begins to replace UH-60s in operation. The Army will then confront a choice in maintaining the long-term affordability of its vertical lift portfolio—whether to simply accept higher O&S costs, accelerate retirements of UH-60s to constrain O&S costs, or retire other aircraft. In the meantime, the work done to develop and test prototype aircraft as part of the FLRAA program can be leveraged to narrow down the uncertainties in the O&S cost estimate process.

The analysis above shows the Army's vertical lift portfolio if O&S costs are as planned, but what happens if O&S costs are higher than expected? The data show that if O&S costs for FARA and FLRAA are 25 percent higher than expected, the Army's O&S costs will increase from FY 2024 to FY 2040 at a 1.52 percent compound annual growth rate (CAGR) compared to the no O&S cost growth scenario's 1.05 CAGR. These data show that higher-than-expected O&S costs won't necessarily fatally injure FVL but controlling O&S costs are a crucial component in the vertical lift fleet. While the Army has several plans to leverage emerging technologies such as digital twinning, MOSA, additive manufacturing, and artificial intelligence-enabled predictive manufacturing to create new maintenance paradigms and reduce maintenance personnel requirements, technological advancement does not always lead to the promised results (see the F-35's Autonomic Logistics Information

System). It is therefore important that the Army look to the lessons learned for managing long-term risk in major acquisition programs and not put all its hopes in the technological basket.

Figure 12: O&S 25 Percent Cost Growth Scenario: Vertical Lift Funding, 2019-2040



Source: U.S. Army Budget documents; Selected Acquisition Reports; *The Military Balance 2019*; CBO; GAO; CSIS analysis.

# Managing Long-Term Risks

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**The decisions the Army makes** in the immediate future will have a lasting impact on the Army's ability to manage the long-term risks of the FARA and FLRAA programs. Many of the decisions made in the next two years will have second and third-order effects on the program over the long-term. There are four primary factors the Army needs to be considerate of in managing the long-term risks of FARA and FLRAA:

- Cost Risk
- Middle Tier of Acquisition
- Industry Incentives
- Program Management

“These data show that higher-than-expected O&S costs won’t necessarily fatally injure FVL but controlling O&S costs are a crucial component in the vertical lift fleet.

## Cost Risk

One of the factors that will affect the Army’s ability to afford FVL is cost risk. Cost risk is the potential that FVL aircraft will cost more than the estimates used in approving and budgeting for the program. Cost risk results from some combination of incorrect assumptions, such as inaccurate cost estimation and unanticipated technical challenges, and

poor program execution, such as changing government requirements and insufficient funding that leads to program delays. Cost risk exists at every stage of any acquisition program, but the ramifications of having cost risk realized vary greatly depending on the phase of the program. The risk that the cost of the design and development program phase will increase is often high in defense acquisition programs due to the challenging nature of the technology being developed. Techniques for managing this risk include applying rigorous systems engineering, maturing technology early, and using digital thread design techniques to quickly implement design changes. However, the consequences of cost growth in the development phase are comparatively less significant than during other phases in the program life cycle because development is a relatively minor percentage of life cycle costs (approximately 5 percent for rotary-wing systems). At the same time, problems identified during development can also lead to increased costs in later, more expensive program stages.

Cost growth in production is a more significant concern because production constitutes roughly 28 percent of life cycle cost. However, cost growth in production may also lend itself more readily to management than cost growth in development because a variety of steps can be taken to reduce production costs, including setting cost-informed requirements (i.e., rescoping requirements that drive significant increases in cost), reducing manufacturing complexity, increasing utilization of automation and tooling in production, and achieving production efficiencies at higher rates of production. RAND has found that, controlling for quantity changes, cost growth in percentage terms is generally higher in development than in production.<sup>33</sup>

Cost growth in sustainment (O&S costs) can have the most severe impact on budgets because sustainment constitutes 68 percent of life cycle costs.

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33. Joseph G. Bolten, Robert S. Leonard, Mark V. Arena, Obaid Younossi, Jerry M. Sollinger, *Sources of Weapon System Cost Growth: Analysis of 35 Major Defense Acquisition Programs* (Santa Monica, CA: RAND, 2008) 28.

Tools for managing these costs may be more limited because they become apparent much later in the program lifecycle, but they include reducing manning levels, altering the maintenance strategy (such as changing the maintenance concept or the balance between contractor and organic support), and adopting techniques such as condition-based maintenance that are designed to reduce the frequency and expense of repairs. More recently, the DoD has also moved toward modular open system designs that would allow it to replace problematic elements in the design over time and escape from vendor lock on these elements, potentially increasing the ability to manage O&S costs through competition over the full program lifecycle.

In the case of FVL, the Army is exploring multiple approaches for managing cost risk. FVL contractors have discussed using digital design thread approaches to their proposed aircraft to enable sophisticated modeling and assessment of design producibility and manufacturing complexity as well as life cycle costs modeling of sustainment. Digital thread also allows the aircraft manufacturers to share this information and modeling with their supply chain so that design updates can be more quickly and cheaply implemented and suppliers can troubleshoot identified issues directly. The Army is also planning to use information developed through the next year or so of the FLRAA program to refine requirements, creating the opportunity to incorporate more cost information into its requirements. Likewise, the FVL contractors will have the opportunity to develop producibility improvements as they work towards a production design. For O&S costs, the Army can work with industry to implement conditions-based maintenance plus for FVL and look to leverage its existing organic maintenance and supply infrastructure to reduce the volume and expense of spare parts, maintenance tooling, and other key life cycle cost drivers. Part of the Army's ongoing JMR-TD project is also working to demonstrate a mission system architecture for FVL, thereby reducing risk in mission systems with potential benefits for O&S costs.

## Middle Tier of Acquisition

The Army has embarked on the process of awarding prototyping contracts for both FARA and FLRAA to rapidly build prototypes as a basis for acquiring new aircraft. Congress has encouraged DoD to use rapid prototyping to accelerate the acquisition process of Section 804 of the National Defense Authorization Act for FY 2016, better known as Middle Tier Acquisition (MTA) authority. Section 804 authorizes defense components to engage in a five-year or less rapid prototyping effort and also provides authority



for procuring systems through a five-year or less rapid fielding effort.<sup>34</sup> These authorities can be used separately or in combination to accomplish the development and procurement of a new defense system. The Army's FARA and FLRAA prototyping efforts will allow for a range of risk reduction activities, including using information from the demonstration and prototyping efforts to inform final requirements for production aircraft by using digital thread design capabilities to rapidly update designs where cost issues are identified. A key issue for accurate cost estimation of FARA and FLRAA is the opportunity in the design and building of the prototypes to see how much advanced manufacturing techniques are able to reduce the cost of producing key aircraft structures and subsystems compared to their historical antecedents. Advanced manufacturing techniques create an opportunity to simplify designs, reduce parts counts, eliminate rework, and streamline assembly processes. Documenting how these techniques actually affect cost requires actually implementing them and measuring the savings achieved as the prototyping process proceeds.

Not all prototyping efforts are alike. Prototyping can be done for a range of purposes, including demonstration of technology, concept development, and production prototyping. A prototype done primarily for technology demonstration or concept development is unlikely to include design features that would be essential in an operational system that are key to a production prototype. Another key factor differentiating prototyping efforts is the presence or absence of competition. Competitive prototyping provides industry with the strongest possible incentives to demonstrate the key capabilities of the system, particularly those that differentiate their design from the competition. At the same time, because the incentive to win the competition is strong, a competitive prototyping effort may focus industry so much on demonstrating the key factors likely to win the competition that other technically challenging issues may receive less focus with a decrement in the risk reduction achieved on those issues. If the demonstration of producibility and reduced cost risk is a significant element of competition, however, competitive prototype designs could provide significant benefits to cost risk. Whether or not rapid prototyping forms the core of an acquisition approach and whether or not a program is formally carried out under MTA, however, does not ultimately change the fundamental engineering task that must be performed to develop and build a new design.

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34. A detailed discussion of MTA can be found at <https://aida.mitre.org/middle-tier/>.

## Incentives

Industry incentives come in several forms. The biggest incentive motivating industry is the desire to be selected as the prime contractor for a program and gain significant contracts for producing that system. This incentive tends to dominate all others and it means that industry incentives are strongest during the period that a new system is being competed. In addition, federal contracts provide both implicit and explicit incentives that incentivize contractor behavior once a contract is awarded. In incentive fee contracts, for example, industry is frequently incentivized by contract terms that require it to share in the expense of any cost overruns or that allows industry to share the benefits of cost underruns. Such incentive provisions can have the effect of reintroducing some aspects of competition, internal to the contractor, when there is not a realistic threat of external competition.

The use of MTA authority directly impacts industry incentives and, as a result, will also impact industry behavior in response to these incentives. This could affect FVL affordability in two ways. First, because the MTA process doesn't provide a guarantee that a prototyping effort will be followed by production, industry may have a reduced incentive to make significant investments in producibility improvements in the prototyping phase. Second, in the part of the MTA process for rapid fielding, the fielding of the system is to be completed in no more than five years. This time frame may prove challenging for FVL and limits the quantities that can be included in the rapid fielding process, again limiting industry's incentive to invest in cost reduction. At the same time, the uncertainties in the MTA process could also raise the prospect for a return of competition, strongly incentivizing industry to meet program objectives. While follow-on fielding remains possible, these implicit incentives resulting from MTA could have an impact on industry efforts to manage cost risk.

## Program Management

Once competition for a program narrows to a single winning bidder, strong program management is likely to be required to ensure that efforts to reduce cost risk and technical risk are maintained. This is likely to be particularly true in an MTA process where implicit programmatic incentives are less clear. This suggests that the Army's program management of FARA and FLRAA is likely to be critical.

It has been some time since the Army has developed a major new aircraft design, and for FVL, the Army plans to run two programs to field new aircraft designs concurrently in the next decade. At the same time, the Army has been procuring and fielding multiple helicopter upgrades

programs over the last decade, revitalizing its Blackhawk, Apache, and Chinook fleets while also acquiring the Lakota aircraft. Within industry, the experience is even broader as the Marine Corps, Navy, and Air Force have developed and procured substantially new or modified designs more recently. This suggests that program management capacity is unlikely to be an issue for the Army, although specific areas of expertise in technology development and integration may present challenges that may be mitigated by experience gained in government and industry from other vertical lift aircraft development programs.

## Conclusion

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**The Army has identified FVL** as one of its top priorities and has also embraced modernization as key to its ability to meet the requirements of the National Defense Strategy. The Army's FY 2020 POM currently projects declining modernization funding overall and declining expenditures on vertical lift. If the Army funds modernization and the aviation portfolio in line with historical averages, it has substantial opportunity to fund development and procurement of FVL. Based on reasonable assumptions on the likely acquisition costs of the FLRAA and FARA programs and costs avoided by retiring current Army aircraft that these programs would replace; this analysis assesses that executing these programs would not meaningfully increase the expense of the Army's vertical lift portfolio in constant dollar terms. Acquiring these aircraft will require a shift of R&D and procurement funding to FVL in the next five years. There is cost risk in both programs which will require active management by the Army. Acquisition cost growth at levels typical of successful acquisition programs would increase the cost of FVL but could likely be handled within the aviation portfolio if carefully managed. In the longer term, the most critical affordability issue for the vertical lift portfolio is likely to be O&S costs, particularly for FLRAA. O&S costs will have to be carefully managed to ensure that the operation of FVL systems remains affordable as higher numbers of these aircraft enter the inventory and to ensure that the Army can afford modernization of the rest of its fleet once FARA and FLRAA are fielded.

“The Army will have to engage a robust set of efforts to manage cost risk in its FVL programs across every stage of the program lifecycle.

The Army will have to engage a robust set of efforts to manage cost risk in its FVL programs across every stage of the program lifecycle, an effort which should include establishing affordability targets for both acquisition and sustainment of these systems as early as possible. Core to the management of cost risk is the ability to properly incentivize industry to

engage with the Army in managing this risk. The Army’s decision on using MTA authority and rapid prototyping as a core element of its approach to FVL will powerfully shape industry’s incentives. A key to success will be ensuring that industry’s incentives stay aligned with the Army’s and are strong enough to spur the necessary investments in managing cost risk.

This paper presents CSIS’s preliminary analysis of the affordability of the Army’s FVL modernization portfolio. Going forward, CSIS will continue refining its vertical lift modernization tool and expanding its analysis to clarify and assess the industrial base implications of the Army’s approach to vertical lift modernization. This analysis will focus on key industry dynamics such as industry workload, innovation capacity, current and future competition, and supply chain resiliency. CSIS plans to release its findings on these key industrial base issues in the winter of 2020.

# About the Authors

**Rhys McCormick** is a fellow with the Defense-Industrial Initiatives Group (DIIG) at CSIS. His work focuses on unmanned systems, global defense industrial base issues, and U.S. federal and defense contracting trends. Prior to working at DIIG, he interned at the Abshire-Inamori Leadership Academy at CSIS and the Peacekeeping and Stability Operations Institute at the U.S. Army War College. He holds an MA in security studies from Georgetown University and a BS in security and risk analysis from the Pennsylvania State University.

**Gregory Sanders** is deputy director and fellow with the Defense-Industrial Initiatives Group at CSIS, where he manages a research team that analyzes data on U.S. government contract spending and other budget and acquisition issues. He employs data visualization and other ways to use complex data collections to create succinct and innovative tables, charts, and maps. His recent research focuses on contract spending by major government departments, contingency contracting in Iraq and Afghanistan, and European and Asian defense budgets. This work requires management of data from a variety of databases, most notably the Federal Procurement Database System, and extensive cross-referencing of multiple budget data sources. In support of these goals, he employs SQL Server, as well as the statistical programming language R. Sanders holds an MA in international studies from the University of Denver and a BA in government and politics, as well as a BS in computer science, from the University of Maryland.

**Andrew Hunter** is a senior fellow in the International Security Program and director of the Defense-Industrial Initiatives Group at CSIS. He focuses on issues affecting the industrial base, including emerging technologies, sequestration, acquisition policy, and industrial policy. From 2011 to November 2014, Mr. Hunter served as a senior executive in the Department of Defense (DOD). Appointed as director of the Joint Rapid Acquisition Cell in 2013, his duties included fielding solutions to urgent operational needs and leading the work of the Warfighter Senior Integration Group to ensure timely action on critical issues of warfighter support. From 2011 to 2012, he served as chief of staff to Ashton B. Carter and Frank Kendall, while each was serving as under secretary of defense for acquisition, technology, and logistics. Additional duties while at DOD include providing support to the Deputy's Management Action Group and leading a team examining ways to reshape acquisition statutes.



From 2005 to 2011, Mr. Hunter served as a professional staff member of the House Armed Services Committee, leading the committee's policy staff and managing a portfolio focused on acquisition policy, the defense industrial base, technology transfers, and export controls. From 1994 to 2005, he served in a variety of staff positions in the House of Representatives, including as appropriations associate for Representative Norman D. Dicks, as military legislative assistant and legislative director for Representative John M. Spratt Jr., and as a staff member for the Select Committee on U.S. National Security and Military/Commercial Concerns with the People's Republic of China. Mr. Hunter holds an MA degree in applied economics from the Johns Hopkins University and a BA degree in social studies from Harvard University.

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1616 Rhode Island Avenue NW  
Washington, DC 20036  
202 887 0200 | [www.csis.org](http://www.csis.org)