



April 2023

FUTURE VERTICAL LIFT AIRCRAFT

Army Should Implement Leading Practices to Mitigate Acquisition Risk

GAO Highlights

Highlights of [GAO-23-105554](#), a report to congressional committees

Why GAO Did This Study

Aircraft capable of vertical take-off and landing—primarily helicopters—support vital Army missions. The Army has been working for decades to develop new capabilities in this area. However, prior efforts were canceled due to cost increases, schedule delays, and performance shortfalls.

A House report included a provision for GAO to review the Army's Future Vertical Lift portfolio. GAO's report addresses (1) planned acquisition approaches, (2) the extent to which cost and schedule estimates align with leading practices, and (3) the extent to which technical risk mitigation aligns with leading practices.

To conduct this work, GAO reviewed acquisition documentation, analyzed cost estimates and schedules, and compared them to leading practices. GAO also interviewed officials from Future Vertical Lift, the Army, and the Office of the Secretary of Defense.

What GAO Recommends

GAO is making seven recommendations to the Army, including that the Future Vertical Lift portfolio improve cost estimates, demonstrate critical technologies prior to starting system development, and conduct a technology risk assessment, as appropriate. The Army concurred with one recommendation, and concurred with the intent of the remaining six.

View [GAO-23-105554](#). For more information, contact Jon Ludwigson at (202) 512-4841 or ludwigsonj@gao.gov.

April 2023

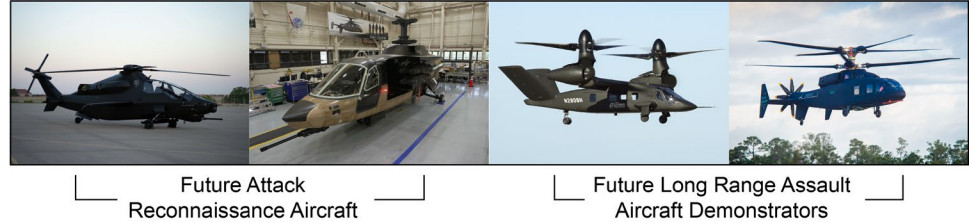
FUTURE VERTICAL LIFT AIRCRAFT

Army Should Implement Leading Practices to Mitigate Acquisition Risk

What GAO Found

The Army is developing several aircraft systems to supplement and replace its aging fleet of helicopters. Aircraft in this portfolio, known as Future Vertical Lift, are to perform attack, transport, and reconnaissance missions, and are designed to have upgraded capabilities—for example, increased payload and range.

Army Future Vertical Lift Prototype Designs and Aircraft Demonstrators



Sources (left to right): © 2022 Bell Textron Inc., © 2022 Sikorsky, a Lockheed Martin Company, and U.S Army (two images on right). | GAO-23-105554

The Army is currently developing two crewed and one uncrewed aircraft systems.

- **Future Attack Reconnaissance Aircraft** is intended to address the Army's capability gap for a dedicated, armed aerial reconnaissance platform, and plans to deliver aircraft in 2030. Acquisition officials are currently conducting an analysis of alternatives and developing two prototypes.
- **Future Long Range Assault Aircraft** is intended to conduct long-range assault missions and serve as a multi-role aircraft to transport personnel and equipment. In fiscal year 2023, the Army reported awarding a contract to a single vendor to complete preliminary design, deliver a virtual prototype, and deliver a physical prototype for flight tests.
- **Future Tactical Unmanned Aircraft System** involves acquiring uncrewed vehicles in phases. The first phase is to meet urgent battlefield needs within 2 years; the next is to develop a new vehicle to conduct reconnaissance missions.

The cost and schedule estimates for these aircraft development efforts did not always meet leading practices. For example, the assault and uncrewed aircraft systems minimally met the threshold for a credible cost estimate. In addition, the business cases for these aircraft systems did not meet leading practices because they did not fully identify schedule risks.

In addition, the plans for the three aircraft systems do not meet leading practices for maturing and assessing technologies. GAO's leading practices recommend demonstrating critical technologies in an operational environment prior to system development. However, the crewed systems plan to demonstrate technologies after that point. Further, the Army is developing the new uncrewed system without first conducting a technology risk assessment.

Without credible cost estimates, operationally demonstrated technologies, and knowledge of associated risks, the Army is in danger of not meeting its goals for fielding these capabilities.

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Abbreviations

ALE	Air Launched Effects
DOD	Department of Defense
FAR	Federal Acquisition Regulation
FARA	Future Attack Reconnaissance Aircraft
FLRAA	Future Long Range Assault Aircraft
FTUAS	Future Tactical Unmanned Aircraft System
FVL	Future Vertical Lift
ITE	Improved Turbine Engine
MOSA	Modular Open System Approach
MTA	middle tier of acquisition
OTA	other transaction agreement

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April 17, 2023

Congressional Committees

Aircraft capable of vertical take-off and landing—primarily, helicopters—help the Army to perform a variety of missions, including attack, transport, and reconnaissance. Current Army helicopters performing these missions—such as the AH-64 Apache and UH-60 Black Hawk—are aging and have undergone multiple upgrades. The Army views its Future Vertical Lift (FVL) portfolio as one of its most critical modernization priorities. It cites a need to improve aircraft capabilities such as maneuverability, lethality, and endurance to keep up with potential adversaries. Over the last 2 decades, the Army has canceled attempts to develop new vertical lift capabilities after experiencing problems during the course of their acquisition. For example, we previously reported that the Comanche helicopter was canceled in 2004 after significant cost increases and schedule delays.¹ Then, we reported that the Armed Reconnaissance Helicopter—the follow on effort to the Comanche—rushed through its planning process and skipped key systems engineering steps. It was determined that the acquisition strategy for the Armed Reconnaissance Helicopter was not executable and the program was terminated in 2008.²

A House Armed Services Committee report accompanying the National Defense Authorization Act for Fiscal Year 2022 contains a provision for GAO to examine the Army’s efforts under the FVL portfolio.³ Our report addresses (1) the capabilities and acquisition approaches under consideration for the FVL portfolio, (2) the extent to which the Army’s cost and schedule estimates for the FVL portfolio align with GAO’s leading practices, and (3) the extent to which the Army has mitigated technical risks for the FVL portfolio in accordance with GAO’s leading practices.

To describe the capabilities and acquisition approaches under consideration for the FVL portfolio, we reviewed acquisition decision

¹GAO, *Defense Acquisitions: Many Analyses of Alternatives Have Not Provided a Robust Assessment of Weapon System Options*, [GAO-09-665](#) (Washington, D.C.: Sept. 24, 2009).

²GAO, *Defense Acquisitions: Strong Leadership is Key to Planning and Executing Stable Weapon Programs*, [GAO-10-552](#) (Washington, D.C.: May 6, 2010).

³H.R. Rep. No. 117-118, pt. 1, at 45-46 (2021); Pub. L. No. 117-81 (2021).

memorandums, acquisition strategies, and capability development documents related to the efforts within the FVL portfolio. To assess the extent to which the Army's cost and schedule estimates for the FVL portfolio align with GAO's leading practices, we reviewed and analyzed FVL portfolio documentation related to the development of those respective estimates. We then compared the cost information against GAO leading practices for cost estimating and the schedule information against GAO's leading practices for a business case to determine the extent to which it conformed to those practices.⁴

To assess the extent to which the Army has mitigated technical risks for the FVL portfolio in accordance with GAO's leading practices, we collected, reviewed, and analyzed FVL portfolio documentation related to the development and assessment of the respective aircraft technologies. We compared this information against GAO leading practices to determine the extent to which it aligned with those practices.⁵ For all objectives, we also interviewed FVL officials, as well as officials from other Department of Defense (DOD) and Army organizations, such as Cost Assessment and Program Evaluation, Deputy Assistant Secretary of the Army (Cost and Economics), and Combat Capabilities Development Command to better understand the plans and estimates associated with the FVL efforts. For more information on our scope and methodology, see appendix I.

We conducted this performance audit from November 2021 to April 2023 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

⁴GAO, *GPS Alternatives: DOD Is Developing Navigation Systems But Is Not Measuring Overall Progress*, [GAO-22-106010](#) (Washington, D.C.: Aug. 5, 2022); *Weapon Systems Annual Assessment: Challenges to Fielding Capabilities Faster Persist*, [GAO-22-105230](#) (Washington, D.C.: June 8, 2022); *Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Program Costs*, [GAO-20-195G](#) (Washington, D.C.: Mar. 12, 2020); *DOD Acquisition Reform: Leadership Attention Needed to Effectively Implement Changes to Acquisition Oversight*, [GAO-19-439](#) (Washington, D.C.: June 5, 2019); and *Best Practices: Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes*, [GAO-02-701](#) (Washington, D.C.: July 15, 2002).

⁵GAO, *Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes*, [GAO/NSIAD-99-162](#) (Washington, D.C.: July 30, 1999).

Background

The current helicopters in the Army's aviation fleet perform a variety of missions and represent different sizes and capabilities. Examples of helicopters currently in the Army's fleet and the missions they perform include:

- AH-64 Apache – attack and reconnaissance
- CH-47 Chinook – heavy lift transport, and
- UH-60 Black Hawk – medium lift, multi-role.

Each of these helicopters has been in service for decades, and the space, weight, and power available to upgrade their avionics and mission systems are reaching their limits. Accordingly, in its 2019 Modernization Strategy, the Army named FVL as one of its six modernization priorities. The efforts within the FVL portfolio are intended to enhance Army aircraft capabilities and replace or supplement portions of the existing fleet. In particular, Army officials have stated they want to develop new platforms that take advantage of improvements in technology to provide for enhanced speed, range, lift, maneuverability, and modern controls. The portfolio is expected to include crewed and uncrewed platforms, capable of attack, reconnaissance, and transport missions on current and future battlefields.⁶

The Army's FVL portfolio currently focuses on developing two crewed and one uncrewed aircraft:

- Future Attack Reconnaissance Aircraft (FARA)
- Future Long Range Assault Aircraft (FLRAA), and
- Future Tactical Unmanned Aircraft System (FTUAS).

DOD Acquisition Pathways

In January 2020, DOD established the Adaptive Acquisition Framework. The framework emphasizes several principles that include simplifying acquisition policy, tailoring acquisition approaches, and conducting data-

⁶For the purposes of this review, we are using the gender-neutral term *uncrewed* as a replacement for the term *unmanned* except when referring to the proper name of an Army program or document.

driven analysis. The Adaptive Acquisition Framework is comprised of six acquisition pathways. The three that are most relevant for this report are:⁷

- Major capability acquisition – supports complex acquisitions, involving the phases of technology development, system development, and production;
- Middle tier of acquisition (MTA) – includes expedited paths for rapid prototyping and rapid fielding, each of which is to be completed within 5 years of initiation;⁸ and
- Urgent capability acquisition – designed to field capabilities in less than 2 years based on identification of vulnerabilities from a combatant commander.

Each pathway has different requirements for milestones, cost and schedule goals, and reporting, but program managers can also combine or transition between pathways based on program goals and the risk associated with the weapon system being acquired. For example, acquisitions using the MTA or urgent capability pathways are generally not subject to the same acquisition and requirements processes as those on the major capability acquisition pathway. For each MTA acquisition using the rapid prototyping path, DOD policy states that components, such as the Army, will develop a process for transitioning successful prototypes to new or existing acquisition programs for production, fielding, and operations and sustainment.⁹ MTA efforts have numerous options for

⁷The Adaptive Acquisition Framework includes three other acquisition pathways. The software acquisition pathway facilitates rapid and iterative delivery of software capability, such as software-intensive systems or software-intensive components or subsystems. Department of Defense Instruction (DODI) 5000.87, *Operation of the Software Acquisition Pathway* (Oct. 2, 2020). The defense business systems pathway supports acquisition of information systems for DOD business operations. DODI 5000.75, *Business Systems Requirements and Acquisition* (Feb. 2, 2017) (incorporating change 2, Jan. 24, 2020). The acquisition of services pathway supports acquisition of services from the private sector such as knowledge-based, construction, facilities, logistics, medical, and transportation. DODI 5000.74, *Defense Acquisition of Services* (Jan. 10, 2020) (incorporating change 1, June 24, 2021). For more information on how DOD is using the Adaptive Acquisition Framework, see [GAO-22-105230](#).

⁸The objective of rapid prototyping is to field a prototype meeting defined requirements that can be demonstrated in an operational environment and provide for residual operational capability within 5 years of the MTA program start date. The objective of rapid fielding is to begin production within 6 months and complete fielding within 5 years of the MTA program start date. DODI 5000.80, *Operation of the Middle Tier of Acquisition (MTA)* (Dec. 30, 2019).

⁹DODI 5000.80.

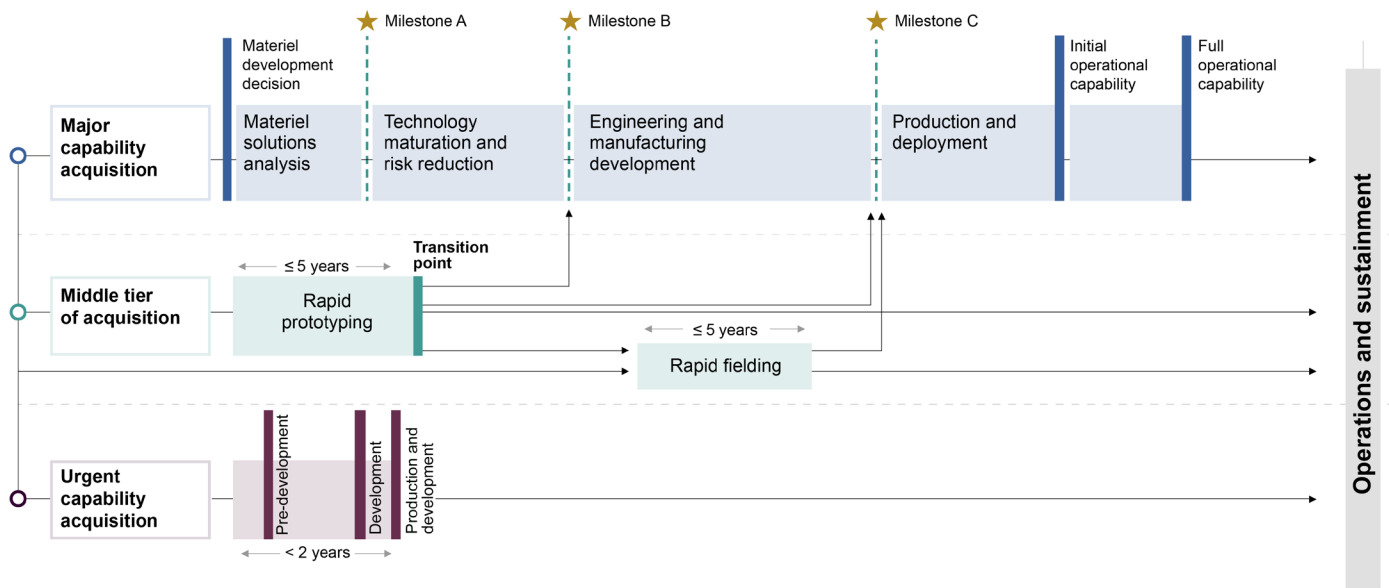
transition, such as transitioning into the rapid fielding path or another acquisition pathway, including the major capability acquisition pathway.

The urgent capability pathway is designed to provide warfighters involved in conflict or preparing for imminent operations with the capabilities needed to overcome unforeseen threats, achieve mission success, and reduce the risk of casualties. The main activities of the urgent capability pathway include pre-development, development, production and deployment, and operations and support, but these activities are designed to take months in contrast to the years it can take for the major capability acquisition pathway. During pre-development activities, a program manager is to perform an analysis of potential courses of action. For each course of action that is approved, the program manager should then develop a draft acquisition strategy and an initial baseline for cost, schedule, and performance based on readily available information. DOD policy states that the documentation requirement for the urgent capability pathway is for the minimal amount necessary to define and execute the program, as well as obtain approval from the appropriate decision authority.¹⁰ Figure 1 shows the major capability acquisition, MTA, and urgent capability pathways.

¹⁰DODI 5000.81, *Urgent Capability Acquisition* (Dec. 31, 2019).

Figure 1: Select Department of Defense Adaptive Acquisition Framework Pathways

Pathway



Source: GAO analysis of Department of Defense data. | GAO-23-105554

Multiple offices and commands within the Army have responsibility for activities associated with the acquisition of weapon systems:

- The Office of the Assistant Secretary of the Army (Acquisition, Logistics and Technology) is the civilian authority responsible for the overall supervision of acquisition matters for the Army. This office oversees 12 program executive offices that acquire different types of systems or equipment across the Army. The program executive office for aviation oversees acquisitions and upgrades of Army aviation programs, including the FVL portfolio.
- In addition, a separate organization, Army Futures Command, determines the capabilities required for these acquisitions. Army Futures Command also develops technologies aimed at achieving these capabilities.
- The Office of the Deputy Assistant Secretary of the Army (Cost and Economics) provides cost analysis support for major weapon acquisitions, such as those in the FVL portfolio, to Army decision makers at all levels.

To facilitate these weapon system investments, the Army can use Federal Acquisition Regulation (FAR)-based contracts, or other agreements that are governed by separate statutes. The FAR establishes uniform policies and procedures for acquisition by all executive agencies, with a guiding principle of delivering on a timely basis the best value product or service to the government customer, while fulfilling public policy objectives. One example of an alternative agreement is known as an other transaction agreement (OTA). The authorities to enter into OTAs enable the Army and companies to negotiate terms and conditions specific to a project without requiring them to comply with most federal regulations that apply to government procurement contracts.¹¹

GAO Leading Practices

GAO has identified leading practices relating to the effective management and oversight of government programs and acquisitions.

- **Cost Estimating and Assessment Guide**, which provides a consistent methodology based on cost-estimating leading practices that can be used across the federal government for developing, managing, and evaluating program cost estimates.¹²
- **Leading Practices for Establishing a Business Case**, which identify that establishing a complete business case is important for programs to make well-informed decisions and set up the acquisition effort for success, including improved cost and schedule performance outcomes. Additionally, for MTA programs, a complete business case helps decision makers identify whether programs using the rapid prototyping path are well-positioned to deliver a residual operational capability within 5 years. Leading practices for establishing a business case, performed prior to the initiation of the MTA pathway, include the completion of: 1) an approved requirements document, 2) an acquisition strategy, 3) a technology risk assessment, 4) an independent cost estimate, and 5) an identification of schedule risk.¹³
- **Leading Practices for Acquisition**, which identify that successful programs take steps to develop a high level of knowledge at key

¹¹For example, Section 4022 of title 10 of the U.S. Code grants DOD the authority to award OTAs for prototype projects that are directly relevant to (1) enhancing the mission effectiveness of military personnel and the supporting platforms, systems, components, or materials proposed to be acquired or developed by the DOD; or (2) improving platforms, systems, components, or materials in use by the armed forces. DOD must meet certain conditions prescribed by law in order to use a prototype OTA.

¹²[GAO-20-195G](#).

¹³[GAO-22-106010](#); [GAO-22-105230](#); [GAO-15-192](#); and [GAO-02-701](#).

decision points—for example, that technologies are sufficiently mature through demonstration in an operational environment prior to system development.¹⁴

Army's Acquisition Approaches Prioritize Rapid Development to Deliver FVL Capabilities

The Army, through the Office of the Assistant Secretary of the Army (Acquisition, Logistics and Technology), approved intended capabilities and the acquisition approaches, which emphasize rapid development, for the FVL portfolio. Documentation for each of the FVL efforts notes the need to get capabilities to the warfighter quickly as a driving factor for planning decisions. In trying to deliver these capabilities, the acquisition offices for these efforts plan to use acquisition approaches that include the major capability acquisition, MTA, and urgent capability pathways.¹⁵ Within those respective acquisition approaches, the acquisition offices are either using, or plan to use, traditional contract types as outlined in the FAR or OTAs.

FARA Following Major Capability Acquisition Pathway with Competitive Prototyping

The Army intends for FARA to address its capability gap for a dedicated, armed aerial reconnaissance platform. The AH-64 Apache has served as an interim solution for performing reconnaissance since the retirement of the OH-58 Kiowa in fiscal year 2019, but the AH-64 lacks capabilities that the Army is seeking for this role. For example, the Army intends for FARA to provide increased range, speed, and ability to deliver munitions at greater distances than that of the AH-64. Planned FARA system attributes include:

- Mission payload – Air Launched Effects, Modular Effects Launcher, and long range precision munitions;
- Range – approximately 1-1/2 times the current capability; and
- Speed – approximately 1-1/2 times the current capability.

According to documentation, FARA officials intend to procure approximately 300 aircraft. Figure 2 shows the two prototype designs the Army is considering for FARA.

¹⁴[GAO/NSIAD-99-162](#).

¹⁵Because the FVL portfolio includes acquisitions that are using the MTA pathway or are in the early stages of the major capability acquisition pathway, for the purposes of this report we refer to these acquisitions as efforts rather than programs.

Figure 2: Future Attack Reconnaissance Aircraft Prototype Designs



Sources (left to right): © 2022 Bell Textron Inc., © 2022 Sikorsky, a Lockheed Martin Company. | GAO-23-105554

FARA is currently following the major capability acquisition pathway and is in the technology maturation and risk reduction phase. In fiscal year 2019, FARA acquisition officials began a two-phase competitive prototyping effort using a prototype OTA. For the second phase of the prototyping effort in March 2020, FARA officials selected two vendors with OTAs—Sikorsky Aircraft Corporation and Bell Textron, Incorporated, respectively—to design, develop, and test a flyable prototype. FARA officials stated that the prototypes are approximately 90 percent complete as of October 2022, and that this phase is scheduled to continue through fiscal year 2024. The competitive prototyping and weapon system preliminary design effort is intended to assist in further developing FARA’s capabilities, as well as reduce risk prior to entering engineering and manufacturing development.

FARA officials had been developing an analysis of alternatives, which was initially scheduled for completion in the third quarter of fiscal year 2022.¹⁶ However, in March 2022, the Army requested permission from the Director of DOD’s Office of Cost Assessment and Program Evaluation to withdraw the analysis based on schedule slips associated with the development and integration of the Improved Turbine Engine (ITE). FARA

¹⁶An analysis of alternatives is used in DOD acquisitions to evaluate key characteristics of multiple systems that are under consideration for procurement. This analysis may be tailored for the specific situation, but can include assessments of performance, suitability, advantages and disadvantages, and estimated costs of the systems proposed to meet the needed capability. When developed in coordination with the initiation of a program, the analysis may be focused on broad trade-offs between a number of different concepts.

officials stated that they do not expect the delay to the analysis of alternatives to significantly affect their timeline for system development. FARA acquisition officials plan to award a FAR-based contract at the start of system development, which is scheduled to begin in fiscal year 2025.

FLRAA Using Middle Tier of Acquisition Pathway to Develop Multiple Prototypes

While FARA is intended to take over the reconnaissance role currently conducted by the AH-64 Apache, the Army plans for FLRAA to supplement and replace portions of its UH-60 Black Hawk fleet. FLRAA is intended to conduct long range assault missions and serve as a multi-role aircraft to transport personnel and equipment. It is projected to have increased maneuverability, speed, and range compared to that of the UH-60 Black Hawk. Initial planned system attributes include:

- Mission payload – crew and service members for air assault missions;
- Range – approximately twice the current capability; and
- Speed – approximately twice the current capability.

According to the acquisition strategy, FLRAA officials intend to procure approximately 600 aircraft. Figure 3 shows the two demonstrator aircraft designs that the Army considered for FLRAA.

Figure 3: Demonstrator Aircraft Used to Inform Potential Future Long Range Assault Aircraft Designs



Source: U.S. Army (images). | GAO-23-105554

The Army initiated FLRAA using the MTA rapid prototyping pathway in fiscal year 2021 and plans to transition the effort to the major capability acquisition pathway at system development. FLRAA acquisition officials chose two vendors—Sikorsky Aircraft Corporation and Bell Textron, Incorporated—to receive OTA awards to begin competitive demonstration

and risk reduction efforts.¹⁷ Officials intended for these efforts to inform performance and design attributes, as well as the range of cost, schedule, and performance trade-offs the Army might consider. In fiscal year 2023, FLRAA acquisition officials reported awarding a FAR-based, hybrid contract to Bell Textron, Incorporated to complete preliminary design, deliver a virtual prototype, and deliver a physical prototype for flight tests in fiscal year 2025.¹⁸ According to Army documentation, the contract was to include nine options, such as those for low-rate initial production and the delivery of aircraft in fiscal year 2030, among others.¹⁹ As outlined in this documentation, the planned options included:

- Engineering manufacturing and design,
- Production of a test aircraft,
- Prototype test and evaluation,
- Long lead materials for low-rate initial production,
- Low-rate initial production,
- Intellectual property data rights and additional stand-alone options, and
- Three single-year options for limited user test aircraft contractor logistics support.

¹⁷The Army selected vendors Sikorsky and Bell as part of a consortium-based OTA. When working with a consortium, the government can award a base OTA that serves as the starting point for negotiations between DOD and consortium members. Upon selecting a consortium member as the awardee for a certain project, DOD can award the project to the consortium, which then issues the award to the consortium member. In other cases, DOD can award the project directly to the consortium member. For more information on DOD's use of consortia awards, see GAO, *Other Transaction Agreements: DOD Can Improve Planning for Consortia Awards*, [GAO-22-105357](#) (Washington, D.C.: Sept. 20, 2022).

¹⁸A hybrid contract contains two or more contract types in its line items. According to Army officials, the contract includes both fixed-price-incentive and cost-reimbursement contract types. A fixed-price-incentive contract provides for adjusting profit and establishing the final contract price by application of a formula based on the relationship of total final negotiated cost to total target cost. The final price of a fixed-price-incentive contract is subject to a price ceiling, negotiated at the outset. FAR 16.403. Under a cost-reimbursement contract, the government agrees to pay the contractor's allowable incurred costs to the extent prescribed in the contract. The contract establishes a ceiling that the contractor may not exceed (except at its own risk) without the approval of the contracting officer. FAR 16.301-1.

¹⁹An option is a unilateral right in a contract, which for a specified time allows the government to purchase additional supplies or services called for by the contract, or extend the term of the contract. FAR 2.101.

FTUAS Using Different Pathways for Multiple Increments of Capability

FTUAS intends to use multiple acquisition pathways to deliver capability to the warfighter. During fiscal year 2022, the Army used the urgent capability pathway for an FTUAS Increment 1 effort to provide immediate uncrewed aircraft capability to select units. Officials awarded a prototype OTA to Arcturus UAV, Incorporated in August 2022 to deliver six prototypes to meet this need during fiscal year 2023. In August 2022, the Army initiated the FTUAS Increment 2 acquisition effort using the MTA rapid prototyping pathway. Officials plan to select multiple vendors for OTA awards for the Increment 2 prototyping effort in fiscal year 2023.

The FTUAS Increment 2 effort is intended to replace the Army's RQ-7B Shadow uncrewed aircraft. The Army plans for the aircraft to be rapidly deployable, have a reduced logistical footprint, and emit less sound than the RQ-7B Shadow. An additional capability for FTUAS would include the ability to take off, deploy, and land in a variety of environmental conditions, including without a runway. The Army intends for FTUAS to enhance its ability to conduct reconnaissance, surveillance, and intelligence gathering missions. In contrast to FARA's planned role, FTUAS would serve as the units' principal reconnaissance and surveillance system for target identification. During a conflict, it could also be equipped with armaments and provide units with early warning and protection. FTUAS documentation noted that the first system is scheduled for delivery in the second quarter of fiscal year 2025, with a total planned quantity of 76 systems.

Army Also Developing Efforts that Cut Across Multiple FVL Capabilities

In addition to the individual planned capabilities for each system, the FVL portfolio also includes two key efforts that cut across systems within the portfolio. The first effort, called Air Launched Effects (ALE), is designed as a multi-mission uncrewed aircraft capable of being launched from FARA and FLRAA. It is intended to extend the operational reach of FARA and FLRAA by penetrating enemy air defenses to detect, identify, and report in different environments. The Army is considering a variety of mission options for ALE including reconnaissance and electronic warfare. It has yet to determine ALE system procurement quantities. In June 2021, the Army approved the use of an OTA for initial prototyping activities to evaluate potential ALE vendors for the air vehicle, payloads, and mission systems.

The second key FVL portfolio effort is a systems architecture, known as Modular Open System Approach (MOSA). FVL officials anticipate that this architecture will permit faster and more frequent upgrades to software, hardware, and subsystems. MOSA is an engineering design approach expected to facilitate interoperable and upgradable components across weapon systems. Through the use of select industry engineering

and design standards, the Army anticipates that MOSA would encourage competition and facilitate future aircraft system upgrades. The Army's program executive office for aviation established a MOSA transformation office to assist with the development of this approach across the FVL portfolio. In April 2022, this office issued an implementation guide meant to help program managers incorporate MOSA principles, respond to challenges, and leverage its benefits to their advantage.

FVL Efforts Inconsistently Applied Leading Practices for Cost and Schedule Estimates

Acquisition offices within the FVL portfolio developed cost estimates and schedules in accordance with Army policies and applicable acquisition pathways, but inconsistently applied leading practices for these estimates. While officials for FLRAA and FTUAS developed more detailed cost estimates than required by DOD and Army MTA policies, we found these estimates did not fully account for our leading practices for credible cost estimates.²⁰ In particular, the estimates do not include substantive sensitivity and risk and uncertainty analyses, which help establish an understanding of how changes to inputs, such as schedules for development or design parameters, affect total program costs. In addition, for FARA, a delay in its analysis of alternatives resulted in a corresponding delay in preliminary cost estimates for these potential alternatives. Further, the acquisition offices within the FVL portfolio have not consistently identified schedule risks and the potential effects of those risks in meeting acquisition timeframes.

FLRAA and FTUAS Cost Estimates Lack Elements of Credibility

FLRAA and FTUAS developed life cycle cost estimates in support of the initiation of their MTA efforts, but these estimates did not consistently reflect our leading practices for developing reliable cost estimates. For FLRAA, the Deputy Assistant Secretary of the Army for Cost and Economics and the FLRAA acquisition office both prepared life cycle cost estimates separately. In turn, the Army's Cost Review Board Working Group reconciled these estimates and issued a draft Army Cost Position in November 2020.²¹ For FTUAS, officials developed an Army Cost

²⁰DODI 5000.80; and Department of the Army, Office of the Assistant Secretary of the Army (Acquisition, Logistics and Technology), *Middle Tier of Acquisition Policy* (Mar. 20, 2020).

²¹The Army Cost Position is used to create a cost basis for Army program baselines, acquisition decisions, and programming and budgeting. It includes a cost analysis brief and a signed affordability memorandum. Because the FLRAA draft Army Cost Position was constructed jointly between the Deputy Assistant Secretary of the Army for Cost and Economics, Program Executive Office, Aviation, and the FLRAA acquisition office to support documentation requirements under the MTA pathway, the draft Army Cost Position does not include an affordability memorandum associated with the full scope of the cost position.

Estimate, reconciled that with the Army's Cost Review Board Working Group, and issued an updated cost estimate in April 2022.

Although not required under DOD and Army MTA policies for rapid prototyping, the FLRAA and FTUAS estimates include costs across the life cycle of the programs, including operations and support costs.²² The FLRAA draft Army Cost Position estimated the life cycle cost to be between approximately \$74 billion and \$76 billion, depending on the design of the aircraft. For FTUAS, cost officials estimated the life cycle cost to be over \$4 billion. We assessed the FLRAA and FTUAS life cycle cost estimates against the four characteristics of reliable cost estimates identified in GAO's Cost Estimating and Assessment Guide: comprehensive, well-documented, accurate, and credible.²³ See the table in appendix I for more detail on the four characteristics.

Comprehensive (Substantially Met): We found that both the FLRAA and FTUAS cost estimates substantially met the comprehensive characteristic. In accordance with leading practices, both cost estimates included life cycle costs and were not limited to the costs of MTA rapid prototyping. The Army cost estimates for FLRAA and FTUAS included costs for research and development, operations and support, and demilitarization. We did not evaluate this characteristic as fully met, however, as the FLRAA cost estimate did not include documented rationale for some ground rules and assumptions. Likewise, we did not evaluate this characteristic as fully met for the FTUAS cost estimate because it was missing certain costs, such as those associated with personnel or facilities.

Well-Documented (Substantially Met): We found that the FLRAA and FTUAS cost estimates substantially met the well-documented characteristic. In accordance with leading practices, both cost estimates included key documentation to understand how the estimate was developed, as well as a description of the methodologies used to develop the estimates, such as analogies to historical aircraft. We did not evaluate this characteristic as fully met for FLRAA because, in part, we found some inconsistencies between the cost model and source documentation. For FTUAS, we did not evaluate this characteristic as fully met, given that the technical baseline that informs the estimate is still under development.

²²DODI 5000.80; and Office of the Assistant Secretary of the Army (Acquisition, Logistics and Technology), *Middle Tier of Acquisition Policy*.

²³[GAO-20-195G](#).

Accurate (Substantially Met): We found that the FLRAA and FTUAS cost estimates substantially met the accurate characteristic. In accordance with leading practices, both cost estimates were based on historical data from applicable programs and were properly adjusted for inflation to ensure the comparisons and projections are valid. We did not evaluate the accurate characteristic as fully met because, among other reasons, we identified concerns with some elements of the methodology in both the FLRAA and FTUAS cost estimates.

Credible (Minimally Met): We found that the FLRAA and FTUAS cost estimates both minimally met the credible characteristic. According to leading practices, credible cost estimates include (1) a sensitivity analysis, (2) a risk and uncertainty analysis, (3) cross-checks, and (4) independent cost estimates. Each of these four elements allows decision makers to understand a program's overall risk. Examples of risks that could be taken into account include potential aircraft design changes or the availability of certain materials to build the aircraft. If risks are not accounted for and analyzed, cost estimators may underestimate or overestimate program costs.

Including a sensitivity analysis and a risk and uncertainty analysis provides a range of possible costs as opposed to a single point estimate.²⁴ Having a range of costs around a point estimate is more useful to decision makers because it conveys the level of confidence in achieving the most likely cost, and also informs them on cost, schedule, and technical risks. Without analyses that provide this range of costs, the estimate will lose credibility because it does not assess the variability in the cost estimate from effects such as schedules slipping, missions changing, and proposed solutions not meeting users' needs. Further, failure to conduct a sensitivity analysis increases the chance that decisions will be made without a clear understanding of how uncertainties could affect costs. Without these analyses, management cannot determine the defensible level of contingency necessary to cover increased costs resulting from such effects.

In addition, credible cost estimates also include cross-checks of major cost elements. A cross-check uses alternate cost estimating methodologies to validate cost estimating results. For example, a methodology based on the cost of historical programs can be used to cross-check other methodologies. Unless an estimate employs cross-

²⁴A sensitivity analysis examines the effect of changing one risk factor at a time and can reveal critical factors that most affect the cost estimate results. A risk and uncertainty analysis examines the effects of many variables changing all at once, and can help decision makers understand a potential range of costs and cost drivers for a program.

checks, the estimate will have less credibility because stakeholders will have no assurance that alternate estimating methodologies produce similar results.

An independent cost estimate is one conducted outside of the acquiring organization, with a comparison of any differences in the estimates. An independent cost estimate frequently uses different methods and is less burdened with organizational bias to create the estimate. Though not required for the MTA pathway, GAO's leading practices emphasize the importance of conducting an independent cost estimate.²⁵ Without an independent cost estimate, decision makers may lack certain insights into a program's potential costs.

We identified several deficiencies that caused the FLRAA cost estimate to minimally meet the credible characteristic. For example, we found that the FLRAA draft Army Cost Position did not include a quantitative sensitivity analysis, but rather officials discussed this internally. The cost estimate also did not include a risk and uncertainty analysis or an independent cost estimate.

The FTUAS cost estimate also minimally met the credible characteristic. Specifically, the sensitivity analysis included in the estimate lacked documentation to show that it was comprehensive, and the risk and uncertainty analysis was limited. The sensitivity analysis relied on varying input parameters by a set percentage from their estimated values. The sensitivity analysis should include clear links between the input parameters, assumptions about these parameters, and the inputs examined by cost estimators. Further, the risk and uncertainty analysis does not apply risk to the majority of the estimate's inputs. Rather, the development phase includes risks for only five inputs, accounting for less than 8 percent of the FTUAS estimated development cost. We also found that while the FTUAS cost estimate used historical data to develop the estimate, it did not include documentation of cross-checks by an alternative method on major cost elements to validate results. It also did not include an independent cost estimate.

FARA Cost Estimates in Development Along With Analysis of Alternatives

FARA officials are still developing documentation for the effort and have not yet developed a life cycle cost estimate. Officials stated they are coordinating on the development of cost estimates for the analysis of

²⁵An independent cost estimate is generally required when entering the major capability acquisition pathway at system development. DODI 5000.85, *Major Capability Acquisition* (Aug. 6, 2020) (incorporating change 1, Nov. 4, 2021). FLRAA plans to enter the major capability acquisition pathway in 2024. The lack of an independent cost estimate, however, has affected the credibility of the FLRAA draft Army Cost Position.

alternatives, as well as for prior to the start of system development, in accordance with DOD policy for the major capability acquisition pathway. They stated these efforts include developing cost estimates for inclusion within the analysis of alternatives, a draft Army Cost Position, and an independent cost estimate. Several offices are expected to coordinate on these efforts, including the offices of the Deputy Assistant Secretary of the Army for Cost and Economics and DOD's Cost Assessment and Program Evaluation, as well as The Research and Analysis Center for the Army. An independent cost estimate for FARA is not required until the completion of its analysis of alternatives. Establishing such an independent cost estimate prior to system development reflects GAO leading practices for establishing a business case.

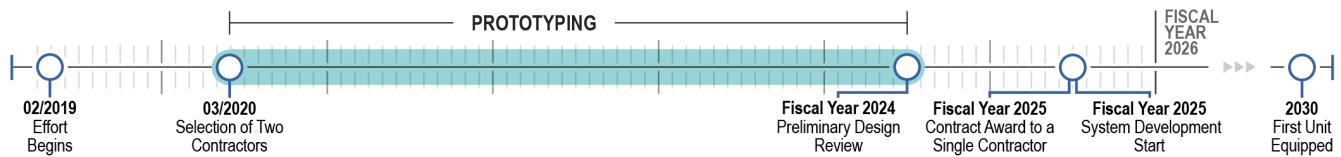
In November 2021, FARA officials provided a briefing on the analysis of alternatives, including potential aircraft designs and cost and schedule risks, to the Office of the Secretary Defense Study Advisory Group. Since that briefing, however, the Army requested permission to withdraw the analysis of alternatives based on schedule delays associated with the ITE. As of October 2022, FARA officials do not have a planned completion date for the analysis of alternatives. DOD's Office of Cost Assessment and Program Evaluation intends to develop an independent cost estimate for FARA prior to the start of its expected system development in fiscal year 2025. Officials from this office stated concerns to us about FARA's technical risk and its cost implications for the planned program.

FVL Efforts Did Not Consistently Identify Schedule Risks

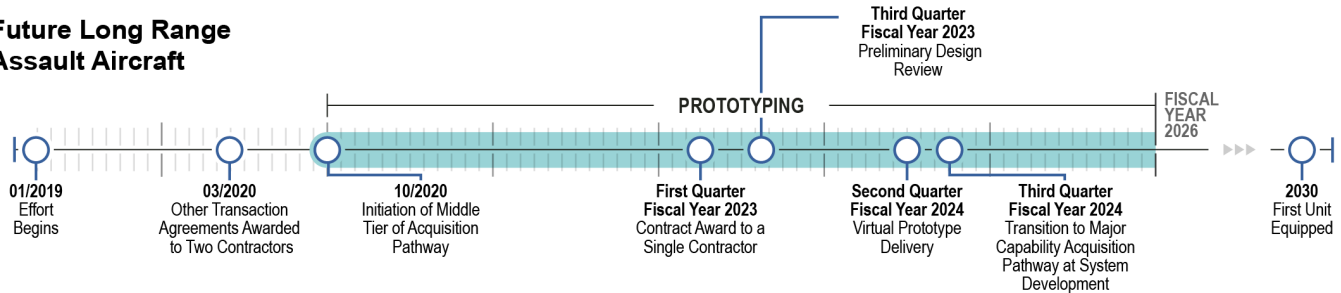
The efforts within the FVL portfolio did not consistently identify risks to their schedules, which is one of our leading practices for establishing a business case. FLRAA and FTUAS have each developed high-level schedule estimates to meet the 5-year time frame associated with the MTA pathway they are pursuing. FLRAA has not, however, updated its schedule risks since initiation in October 2020, and FTUAS has not identified any risks to its schedule. Although FARA has not yet finalized its analysis of alternatives, it is pursuing a fiscal year 2030 date to equip its first unit. Figure 4 depicts the planned schedules for the FVL portfolio efforts.

Figure 4: Planned Schedules for Future Vertical Lift Portfolio Efforts

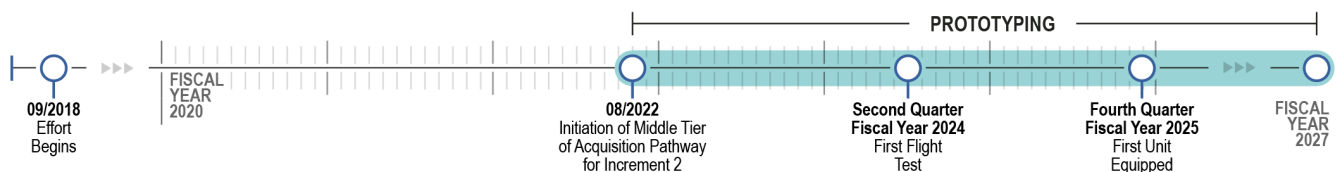
**Future Attack
Reconnaissance Aircraft**



**Future Long Range
Assault Aircraft**



**Future Tactical Unmanned
Aircraft System**



Source: GAO analysis of Department of Defense data. | GAO-23-105554

Note: In this figure, the dates for which each “effort begins” correspond to initial activities for the respective efforts that we identified through our review of associated documentation.

Identifying and describing schedule risk throughout an acquisition effort is critical to mitigating risk. Army policy requires that programs using the MTA pathway describe the program schedule, as well as schedule risks, within the acquisition strategy. The policy also requires the program manager to update Army leadership on the program’s status with respect to cost, schedule, and performance objectives to support the program’s annual budget request.²⁶ In addition, one element of our leading practices for establishing a business case is that programs identify schedule risks

²⁶Office of the Assistant Secretary of the Army (Acquisition, Logistics and Technology), *Middle Tier of Acquisition Policy*.

in order to inform decision makers about the paths or activities that are most likely to delay the program. For MTA programs, a complete business case helps decision makers identify whether programs using the rapid prototyping path are well-positioned to deliver a residual operational capability within 5 years. Our past work found that programs should identify risks to the schedule in support of major decisions and significant events or program milestones. These decisions and events can include production decisions, contract awards, and annual budget request submissions, among others.²⁷

We reviewed the FLRAA, FTUAS, and FARA schedules and found that while these efforts identified some risks in accordance with Army policy, FLRAA and FTUAS did not identify and assess risks to their schedules in support of major decisions. FLRAA and FTUAS officials do not plan to conduct analyses of schedule risks until after contract award, a significant event for which knowledge of schedule risks could help Army decision makers.

- We found that FLRAA's acquisition strategy identified potential schedule risks, such as the timelines associated with developing the aircraft's new flight control software and hardware, as well as schedule risks if delays occurred in vendor selection. For example, the FLRAA acquisition strategy identified its constrained schedule as a high risk and stated that if FLRAA did not award its contract to a single vendor by February 2022, equipping its first unit in fiscal year 2030 would be unachievable. FLRAA officials reported awarding this contract in December 2022. FLRAA officials plan to conduct an analysis of schedule risks in fiscal year 2023 after contract award, in association with system development and generation of an integrated master schedule. Without updating risks to the schedule prior to making major decisions or having significant events, FLRAA decision makers may lack the ability to assess the likelihood of meeting objectives. Delays to the schedule could also affect FLRAA estimated costs and associated annual budget requests.
- We found that the FTUAS acquisition strategy identified certain technical risks to the effort, such as not meeting airworthiness engineering capabilities, but it did not identify any schedule risks. FTUAS officials told us they plan to conduct an analysis of schedule risks after contract award, in association with the generation of an

²⁷GAO-22-106010; *Schedule Assessment Guide: Best Practices for Project Schedule*, GAO-16-89G (Washington, D.C.: Dec. 22, 2015); and *Best Practices: Using a Knowledge-Based Approach To Improve Weapon Acquisition*, GAO-04-386SP (Washington, D.C.: Jan. 1, 2004).

integrated master schedule. They also stated that plans for the effort continue to evolve, which makes a continuous assessment of schedule risk even more critical. Without identifying schedule risks in advance of awarding a contract, decision makers lack key knowledge about the effect of potential schedule delays, including effects on the FTUAS planned budget.

- Similar to cost, FARA has not yet developed documentation of schedule risks. In 2020, FARA began to develop an analysis of alternatives for potential aircraft and risks to meeting its planned schedule. For example, an identified schedule risk for FARA is the engine that will go into the aircraft—the ITE, which is managed under a separate program office. According to acquisition officials, the ITE has already experienced a delay due to the COVID-19 pandemic. FARA now expects to take delivery of its first ITE in the spring of fiscal year 2023 and then complete ground-based testing prior to its first prototype demonstration flights. In addition, the completion of the analysis of alternatives itself and selection of aircraft design has already been delayed by over 6 months. FARA officials stated that they still plan to meet their timelines, including issuing a request for proposal in mid-2023 and starting system development in mid-2025, despite the analysis of alternatives remaining incomplete. Officials outside the effort have expressed concern about FARA’s schedule. For example, officials from the Army’s Research and Analysis Center stated that their initial analysis found FARA’s schedule to be aggressive, relying on consistent success and concurrency in development and testing. In addition, they noted that if FARA experiences technical issues but keeps to its current planned schedule, costs for the effort could increase significantly. We previously reported that attaining technology, design, and manufacturing knowledge concurrently is a major cause of schedule delays and cost increases for DOD weapon system programs.²⁸

FVL Portfolio Technology Risk Mitigation Is Not Consistent with Leading Practices

²⁸[GAO/NSIAD-99-162](#).

FARA and FLRAA Plans for Technology Maturation Do Not Meet Leading Practices

The Army does not plan to demonstrate all FARA and FLRAA critical technologies in an operational environment prior to system development, a GAO leading practice for acquisition. FARA officials identified four critical technologies that the effort will evaluate for maturity prior to reaching development start in 2025:

- The ITE,
- Modular Effects Launcher,
- Area Weapons System (Cannon), and
- Digital Backbone.

Of these technologies, only the ITE is approaching full maturity. The other three critical technologies are currently immature, with officials reporting that the technology components have been tested in a relevant environment. For example, testing in a relevant environment could include a high fidelity laboratory environment or in a simulated realistic environment. Technologies are considered fully mature when they can be demonstrated in an operational environment in their anticipated form, fit, and function. FARA plans to fully mature the ITE and Digital Backbone in an operational environment prior to the start of system development in 2025. However, officials do not plan to fully mature the Modular Effects Launcher and Area Weapons System (Cannon) by the start of system development.

For FLRAA, officials identified two critical technologies, Fly-by-Wire Advance Flight Controls and the Drive System/Gear Box, and noted that these technologies are approaching full maturity. The Joint Multi-Role Technology Demonstrator—a predecessor aircraft technology development effort—helped evaluate these technologies over the last decade, including flight testing. FLRAA officials stated that testing has been completed on one demonstrator aircraft and will be completed on the other demonstrator aircraft in December 2022.

However, FLRAA plans to develop only virtual system prototypes during its MTA rapid prototyping effort. These virtual prototypes will consist of: (1) a digital engineering model of the FLRAA aircraft and mission equipment, and (2) a crew station simulator for a pilot and copilot that replicates the cockpit design and planned functionality. By developing virtual prototypes rather than a physical one, officials will not be able to demonstrate FLRAA critical technologies in an operational environment prior to system development. DOD and Army policies state that virtual prototypes are acceptable if they result in a residual operational capability that can be fielded. However, DOD policy for the MTA pathway broadly states that a residual operational capability “will be considered any

military utility for an operational user that can be fielded,” and does not define what is considered a fieldable military capability.²⁹ Officials from the Under Secretary of Defense for Acquisition and Sustainment expressed skepticism about what to expect from a virtual prototype. An official from the Army’s Combat Capabilities Development Command was similarly skeptical in discussion with us about how FLRAA would demonstrate operational capability through virtual prototypes.

According to our leading practices for acquisition, programs should fully mature all critical technologies in an operational environment by the start of system development.³⁰ According to Army officials, critical technologies for both FARA and FLRAA will not achieve this level of maturity. This creates a danger of limited insight into key technology risks. Leading practices for knowledge-based acquisitions state that each of the critical technologies should be demonstrated in an operational or realistic environment—not simply in a relevant environment—prior to their incorporation into a system design to ensure that they work as intended for the end user. Demonstrating each technology in only in a relevant environment could raise FARA and FLRAA costs and extend timelines for delivery of equipment to the warfighter. In 2019, we made a priority recommendation that the Army demonstrate the technologies it is developing for modernization in an operational environment prior to starting system development.³¹ The Army concurred with this recommendation. The plans for technology demonstrations for both FARA and FLRAA, however, are inconsistent with this recommendation and put the Army at risk in developing its FVL capabilities.

FLRAA and FTUAS Plans for Technology Assessment Do Not Meet Leading Practices

The Army initiated the FLRAA MTA rapid prototyping effort in October 2020 without a technology risk assessment, a condition that does not meet GAO leading practices for establishing a business case. DOD and Army policies require an identification of technical risks at initiation within the acquisition strategy. FLRAA’s acquisition strategy identified design risks stating that if the system’s size, weight, and drag changes beyond their design models, then the system may not be able to meet its performance attributes. The acquisition strategy identified this as a

²⁹DODI 5000.80.

³⁰DOD policy implements statutory requirements and states that programs following the major capability pathway should, at a minimum, demonstrate technologies in a relevant environment before system development. DODI 5000.85; 10 U.S.C. § 4252(a). This does not preclude program officials from pursuing a higher level of maturity.

³¹GAO, *Army Modernization: Steps Needed to Ensure Army Futures Command Fully Applies Leading Practices*, [GAO-19-132](#) (Washington, D.C.: Jan. 23, 2019).

moderate risk, but of significant consequence if realized, which the Army planned to address through its competitive demonstration and risk reduction activities. While this is a design risk with technical implications, the acquisition strategy does not identify specific technologies that could contribute to or potentially mitigate this risk. Officials stated that they plan to conduct a technology risk assessment prior to the start of system development in 2024.

Similarly, the Army initiated the FTUAS MTA rapid prototyping effort for Increment 2 in August 2022 without performing a technology risk assessment. FTUAS officials stated that technologies for uncrewed aircraft are already widely understood and in use. For example, FTUAS Increment 1 uses existing, commercially available technology. As a result, officials have not identified any critical technologies needed for Increment 2. Further, FTUAS officials stated that they have not developed a technology risk assessment for Increment 2 because they have not selected a specific vendor solution. They stated that they plan to perform the technology risk assessment in phases from fiscal year 2023 through fiscal year 2024 as part of that selection. We previously reported that contractors may be overly optimistic about the maturity of critical technologies, especially prior to contract award.³² Conducting a technology risk assessment before awarding a contract could help FTUAS decision makers understand the risks involved in making a vendor selection.

We also previously reported that a formal technology risk assessment performed at the initiation of a program is a leading practice for establishing that program's business case.³³ The principle is not to avoid technical risk, but rather identify risk early and resolve it prior to the start of product development.³⁴ Without technology risk assessments, Army decision makers lack insight into whether FLRAA and FTUAS, as efforts using the MTA rapid prototyping pathway, are well-positioned to deliver residual operational capabilities within 5 years.

Conclusions

Faced with an aging fleet of helicopters and canceled attempts to modernize it, the Army needs the capabilities that the FVL portfolio plans

³²GAO, *Technology Readiness Assessment Guide: Best Practices for Evaluating the Readiness of Technology for Use in Acquisition Programs and Projects* [Reissued with revisions on Feb. 11, 2020], [GAO-20-48G](#) (Washington, D.C.: Jan. 7, 2020).

³³[GAO-22-105230](#).

³⁴GAO, *Weapon System Requirements: Detailed Systems Engineering Prior to Product Development Positions Programs for Success*, [GAO-17-77](#) (Washington, D.C.: Nov. 17, 2016).

to deliver and is understandably expediting the acquisitions of FVL aircraft. But key to making the right decisions on the elements of the FVL portfolio is building sound business cases for each—that is, having robust estimates of what each will cost, and the risks associated with their respective schedules and technologies. While the three FVL efforts followed DOD policy for their respective acquisition pathways, providing better information on their cost, schedule, and technology to decision makers could lead to better outcomes.

The Army developed cost estimates for FLRAA and FTUAS, but they lacked key analysis that leadership could use to support planning and budgeting. The cost estimates for the efforts substantially met three of four characteristics—comprehensive, well-documented, and accurate—and therefore are better positioned to inform decision makers. In contrast, the credible characteristic was minimally met for both efforts, casting doubt on the reliability of these estimates. In particular, as the efforts transition from the MTA pathway, an improved cost estimate that meets all four elements of the credible characteristic could enhance opportunities for oversight and accountability.

In addition, the FLRAA and FTUAS efforts worked to develop schedules, but shortfalls in risk evaluation reduced their usefulness. The lack of fully evaluated schedule risks for FLRAA and FTUAS will likely affect the timing of fielding these capabilities. The Army is also missing important information about the technologies it is developing for the FVL portfolio. For example, without a technology risk assessment for FTUAS, Army leadership does not have insight on the maturity of proposed approaches.

Consistently applying leading practices for assessing and mitigating risks for cost, schedule, and technology is critical to ensuring the successful delivery of FVL capabilities and avoiding delays and cost overruns. Doing so will increase the likelihood of delivering needed capabilities to the warfighter in a timely manner.

Recommendations for Executive Action

We are making the following seven recommendations to the Army:

The Secretary of the Army should ensure that the Future Long Range Assault Aircraft effort updates its life cycle cost estimate to align with all four elements of the credible characteristic as identified in GAO's Cost Estimating and Assessment Guide. (Recommendation 1)

The Secretary of the Army should ensure that the Future Tactical Unmanned Aircraft System effort updates its life cycle cost estimate to align with all four elements of the credible characteristic as identified in GAO's Cost Estimating and Assessment Guide. (Recommendation 2)

The Secretary of the Army should ensure that the Future Long Range Assault Aircraft effort identifies and analyzes schedule risks prior to major events, such as its annual budget request. (Recommendation 3)

The Secretary of the Army should ensure that the Future Tactical Unmanned Aircraft System effort identifies and analyzes schedule risks prior to major events, such as its contract award for Increment 2. (Recommendation 4)

The Secretary of the Army should ensure that the Future Attack Reconnaissance Aircraft effort plans to demonstrate all of its critical technologies in an operational environment by the start of system development. (Recommendation 5)

The Secretary of the Army should ensure that the Future Long Range Assault Aircraft effort plans to demonstrate all of its critical technologies in an operational environment by the start of system development. (Recommendation 6)

The Secretary of the Army should ensure that the Future Tactical Unmanned Aircraft System effort conducts a technology risk assessment prior to contract award for Increment 2. (Recommendation 7)

Agency Comments and Our Evaluation

We provided a draft of this report to the Army for review and comment. In its comments, reproduced in Appendix II, the Army concurred with one of our seven recommendations, and concurred with the intent of the remaining six. The Army concurred with our recommendation to ensure that the FLRAA effort identify and analyze schedule risks prior to major events. In concurring with the intent of our remaining six recommendations, the Army acknowledged the importance of updating cost estimates, identifying and analyzing schedule risks, maturing technologies, and conducting technology risk assessments. In its concurrence, however, the Army stated it would address these concerns in accordance with existing DOD policy. The Army stated that it has established its plans and actions for the FVL portfolio in accordance with this policy. We described these plans in our report, but also described how they fall short of leading practices for each of these areas. The leading practices that form the basis of our recommendations are in keeping with DOD policy but also exceed it in some areas. We found that DOD could do more to implement these practices, and, in doing so, can further reduce risk for acquisition programs. As a result, we did not make changes to the recommendations.

We are sending copies of this report to the appropriate congressional committees, the Secretary of Defense, the Secretary of the Army, and other interested parties. In addition, the report is available at no charge on the GAO website at <https://www.gao.gov>.

If you or your staff have any questions about this report, please contact me at (202) 512-4841 or LudwigsonJ@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix III.

A handwritten signature in black ink that reads "Jon Ludwigson". The signature is written in a cursive, flowing style with a long horizontal tail on the final letter.

Jon Ludwigson
Director, Contracting and National Security Acquisitions

List of Committees

The Honorable Jack Reed
Chairman
The Honorable Roger Wicker
Ranking Member
Committee on Armed Services
United States Senate

The Honorable Jon Tester
Chair
The Honorable Susan Collins
Ranking Member
Subcommittee on Defense
Committee on Appropriations
United States Senate

The Honorable Mike Rogers
Chairman
The Honorable Adam Smith
Ranking Member
Committee on Armed Services
House of Representatives

The Honorable Ken Calvert
Chair
The Honorable Betty McCollum
Ranking Member
Subcommittee on Defense
Committee on Appropriations
House of Representatives

Appendix I: Objectives, Scope, and Methodology

This report (1) describes the capabilities and acquisition approaches under consideration for the Future Vertical Lift (FVL) portfolio; (2) assesses the extent to which the Army's cost and schedule estimates for the FVL portfolio align with GAO's leading practices; and (3) assesses the extent to which the Army has mitigated technical risks for the FVL portfolio in accordance with GAO's leading practices.

To describe the capabilities and acquisition approaches for the FVL portfolio, we reviewed documentation such as acquisition decision memorandums, acquisition strategies, and capability development documents related to the efforts within the FVL portfolio. We also interviewed officials from the respective FVL efforts, as well as knowledgeable officials from other Department of Defense (DOD) and Army offices, to better understand the capabilities being developed and acquisition approaches being used across the FVL portfolio. From DOD, this included officials from the offices of the Under Secretary of Defense for Acquisition and Sustainment and Cost Assessment and Program Evaluation. From the Army, this included officials from the offices of the Assistant Secretary of the Army (Acquisition, Logistics and Technology) and Deputy Assistant Secretary of the Army (Cost and Economics), as well as the FVL Cross-Functional Team, Combat Capabilities Development Command, and The Research and Analysis Center.

To assess the extent to which the Future Long Range Assault Aircraft (FLRAA) and Future Tactical Unmanned Aircraft System (FTUAS) life cycle cost estimates align with leading practices, we obtained and analyzed the FLRAA and FTUAS life cycle cost estimates and documentation supporting the Army's cost estimating practices. This documentation included an estimating model, budget data, and management briefings and reports. We assessed FLRAA and FTUAS cost estimates by comparing the estimates and supporting documentation to the leading practices discussed in GAO's Cost Estimating and Assessment Guide.¹ These practices have been found to be the basis for reliable cost estimates. Specifically, we reviewed each cost estimate against leading practices to support four characteristics—comprehensive, well-documented, accurate, and credible—which are described in table 1.

¹GAO, *Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Program Costs*, [GAO-20-195G](#) (Washington, D.C.: Mar. 12, 2020).

Appendix I: Objectives, Scope, and Methodology

We assessed each of the characteristics listed below as fully met, substantially met, partially met, minimally met, or not met.²

Table 1: Four Characteristics of a Reliable Cost Estimate and Summary of Leading Practices

Characteristic	Summary of leading practices
Comprehensive	Comprehensive cost estimates completely define the program and reflect the current schedule and technical baseline. They are structured with sufficient detail to ensure that cost elements are neither omitted nor double-counted. Where information is limited and judgments must be made, assumptions and exclusions on which the estimate is based are reasonable, clearly identified, explained, and documented.
Well-documented	Well-documented cost estimates can easily be repeated or updated and can be traced to original sources through auditing. Thorough documentation explicitly identifies the primary methods, calculations, results, rationales or assumptions, and sources of the data used to generate each cost element's estimate.
Accurate	Accurate cost estimates are developed by estimating each cost element using the best methodology from the data collected. Accurate estimates are based on appropriate adjustments for inflation. Their underlying mathematical formulas, databases, and inputs are validated, and the resulting estimates contain few, if any, minor mathematical mistakes. Accurate estimates are based on a historical record of cost estimating and actual experiences from comparable programs. Finally, they are updated regularly to reflect significant changes in the program. Any variances between estimated and actual costs are documented, explained, and reviewed.
Credible	Credible cost estimates discuss and document any limitations of the analysis, including uncertainty or bias surrounding source data and assumptions. The estimate's major assumptions are varied to determine how sensitive it is to changes. Credible cost estimates include a risk and uncertainty analysis that determines the level of confidence associated with the estimate. In addition, high-value cost elements are cross-checked with alternative estimating methodologies to validate results. Finally, the estimate is compared with an independent cost estimate conducted by a group outside the acquiring organization.

Source: GAO-20-195G. | GAO-23-105554

To assess the extent to which Future Attack Reconnaissance Aircraft (FARA), FLRAA, and FTUAS high-level schedules align with leading practices for a business case, we first reviewed existing DOD Instructions and Army policy for schedule documentation required to be completed by each of these efforts.³ We then requested, obtained, and reviewed available schedule and acquisition documentation. We compared these documents against DOD and Army requirements for major capability acquisitions and the MTA pathway in order to determine the extent to

²Fully met—the Army provided complete evidence that satisfies the entire criterion; substantially met—the Army provided evidence that satisfies a large portion of the criterion; partially met—the Army provided evidence that satisfies about half of the criterion; minimally met—the Army provided evidence that satisfies a small portion of the criterion; and not met—the Army provided no evidence that satisfies any of the criterion.

³Department of Defense Instruction (DODI) 5000.80, *Operation of the Middle Tier of Acquisition (MTA)* (Dec. 30, 2019); DODI 5000.81, *Urgent Capability Acquisition* (Dec. 31, 2019); DODI 5000.85, *Major Capability Acquisition* (Aug. 6, 2020) (incorporating change 1, Nov. 4, 2021); and Department of the Army, Office of the Assistant Secretary of the Army (Acquisition, Logistics and Technology), *Middle Tier of Acquisition Policy* (Mar. 20, 2020).

which the FVL efforts identified and assessed risks to their respective schedules in accordance with policy.

We then compared these documents against GAO's leading practices for establishing a business case, specifically the practice of identifying schedule risk. Further, the identification of schedule risk is to occur prior to the initiation of an acquisition. We reviewed the respective FVL portfolio schedule documentation in order to determine (1) the extent to which the FVL efforts identified and assessed risks to their respective schedules, and (2) the extent to which these identifications and assessments occurred prior to initiation.⁴

To assess the extent to which the Army has mitigated technical risks for the FVL portfolio in accordance with leading practices, we collected and reviewed FVL portfolio documentation related to the assessment of the respective aircraft technologies. We then compared this information against GAO leading practices for acquisition, specifically the practice of having fully mature technologies at the start of system development. We made this comparison to determine the extent to which the FVL portfolio plans to have fully mature technologies at the start of system development.

In addition, we compared the FVL portfolio documentation against GAO's leading practices for establishing a business case, specifically the practice of identifying and assessing technical risk. Further, the identification of technical risk is to occur prior to the initiation of an acquisition. We reviewed the respective FVL portfolio documentation in order to determine (1) the extent to which the FVL efforts identified and assessed technical risks, and (2) the extent to which these identifications and assessments occurred prior to initiation.

We conducted this performance audit from November 2021 to April 2023 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

⁴GAO, *GPS Alternatives: DOD Is Developing Navigation Systems But Is Not Measuring Overall Progress*, [GAO-22-106010](#) (Washington, D.C.: Aug. 5, 2022); *Weapon Systems Annual Assessment: Challenges to Fielding Capabilities Faster Persist*, [GAO-22-105230](#) (Washington, D.C.: June 8, 2022); and *Best Practices: Using a Knowledge-Based Approach To Improve Weapon Acquisition*, [GAO-04-386SP](#) (Washington, D.C.: Jan. 1, 2004).

Appendix II: Comments from the Department of the Army



SECRETARY OF THE ARMY
WASHINGTON

MAR 14 2023

Mr. Jon Ludwigson
Director
Contracting and National Security Acquisitions
U.S. Government Accountability Office
441 G Street, NW
Washington, DC 20548

Dear Mr. Ludwigson:

This is the Department of Defense (DoD) response to the GAO Draft Report, GAO-23-105554, "FUTURE VERTICAL LIFT AIRCRAFT: Army Should Implement Leading Practices to Mitigate Acquisition Risk," dated November 30, 2022 (GAO Code 105554).

The DoD concurs with the intent of the draft report. For your consideration in Enclosure 1, we have provided updated language for Recommendations 1, 2, 4, 5, 6, and 7 that enables the Army to address these concerns within current DoD policy.

The DoD appreciates the opportunity to review the draft report. My point of contact is Mr. Dale N. Fletcher, Office of the Assistant Secretary of the Army (Acquisition, Logistics, and Technology), dale.n.fletcher.civ@army.mil or 703-614-8694.

Sincerely,

A handwritten signature in black ink, reading "Christine E. Wormuth", is positioned above the typed name.

Christine E. Wormuth

Enclosures

Enclosure 1

**GAO DRAFT REPORT, GAO-23-105554, DATED November 30, 2022 (GAO CODE
105554)**

**“FUTURE VERTICAL LIFT AIRCRAFT: ARMY SHOULD IMPLEMENT LEADING
PRACTICES TO MITIGATE ACQUISITION RISK”**

DEPARTMENT OF THE ARMY (DA) COMMENTS

GAO RECOMMENDATION 1: Secretary of the Army, ensure the Future Long Range Assault Aircraft (FLRAA) effort updates its lifecycle cost estimate to align with all four elements of the credible characteristics as identified in GAO’s Cost Estimating and Assessment Guide.

DA RESPONSE: The Army concurs with the intent of this recommendation and acknowledges the need to update the FLRAA cost estimate. In completing this update, we favor the use of established Army cost estimating policies and guidance in lieu of the methodology recommended in the GAO report. The Deputy Assistant Secretary of the Army for Cost and Economics (DASA(CE)) will lead this effort. As an example, for FLRAA’s Middle Tier of Acquisition (MTA) phase of the program, the Army (DASA(CE) and the Project Office) initiated a rigorous cost review board working group that considered different methodologies and approaches. An independent cost estimate, statutorily required for the Milestone B, will be conducted prior to initiating the Major Capability Acquisition phase of the program.

The Army recommends rewording the recommendation to: “Secretary of the Army, ensure the FLRAA effort updates its lifecycle cost estimate in accordance with governing DoD policy.”

GAO RECOMMENDATION 2: Secretary of the Army, ensure the Future Tactical Unmanned Aircraft System (FTUAS) effort updates its lifecycle cost estimate to align with all four elements of the credible characteristics as identified in GAO’s Cost Estimating and Assessment Guide.

DA RESPONSE: The Army concurs with the intent of this recommendation and acknowledges the need to update the FTUAS cost estimate and has directed the DASA(CE) to accomplish that. Again, we favor the use of established Army cost estimating policies and guidance as opposed to GAO’s recommended methodology. As identified in the GAO Report, “FTUAS developed more detailed cost estimates than required by DoD and Army MTA policies” and we will continue to work with DASA(CE) to update lifecycle cost estimates as the program progresses to a program of record. The Army conducted a cost review board working group to determine affordability and considered different methodologies and approaches.

**DEPARTMENT OF THE ARMY (DA) COMMENTS
GAO DRAFT REPORT, GAO-23-105554**

The Army recommends rewording the recommendation to: "Secretary of the Army, ensure the FTUAS effort updates its lifecycle cost estimate in accordance with governing DoD policy."

GAO RECOMMENDATION 3: Secretary of the Army, ensure the FLRAA System effort identifies and analyzes schedule risk prior to major events, such as its annual budget request.

DA RESPONSE: The Army concurs with this recommendation and will continue to identify and analyze schedule risk to the program.

GAO RECOMMENDATION 4: Secretary of the Army, ensure the FTUAS effort identifies and analyzes schedule risk prior to major events, such as contract award for Increment (Inc) 2.

DA RESPONSE: The Army concurs with the intent of this recommendation. The FTUAS Program Office identifies and analyzes schedule risk prior to major events. The capabilities demonstration with multiple vendors informed the FTUAS Inc 2 Abbreviated Capability Development Document (A-CDD) allowing for a reasonable assessment of technical maturation and schedule milestones. Additionally, the competitive down-select strategy of the FTUAS Inc 2 MTA Rapid Prototyping (RP) allows for continuous assessment of both vendor progress and schedule risk. These assessments inform Program Office Estimate (POE) updates in support of the annual Army Affordability Assessment. Specifically, the Project Manager (PM) Unmanned Aircraft Systems (UAS) evaluation criteria requires a schedule risk assessment, of each vendor, as part of the Other Transaction Authority (OTA) process.

The Army recommends rewording the recommendation to: "Secretary of the Army, ensure the FTUAS effort identifies and analyzes schedule risk in accordance with governing DoD policy."

GAO RECOMMENDATION 5: Secretary of the Army, ensure the Future Attack Reconnaissance Aircraft (FARA) effort plans to demonstrate all its critical technologies in an operational environment by the start of system development.

DA RESPONSE: The Army concurs with the intent of this recommendation and wishes to clarify that demonstration of technologies in an operational environment is not required until Milestone C. At that time, we will have demonstrated all critical technology elements in the operational environment. The Army conducted significant risk reduction and demonstration activities on these critical technologies and will continue to do so over the next two to three years leading up to Milestone B and to the start of system development. The program schedule included extensive laboratory and prototype flight testing prior to system development based on lessons learned from past programs. The Army looks forward to demonstrating each of these critical technologies through the competitive prototype flight program prior to system development.

**DEPARTMENT OF THE ARMY (DA) COMMENTS
GAO DRAFT REPORT, GAO-23-105554**

The Army recommends rewording the recommendation to: "Secretary of the Army, ensure the FARA effort plans to demonstrate its critical technologies in accordance with governing DoD policy."

GAO RECOMMENDATION 6: Secretary of the Army, ensure that the FLRAA effort plans to demonstrate all its critical technologies in an operational environment by the start of system development.

DA RESPONSE: The Army concurs with the intent of this recommendation and recommends clarifying that demonstration in an operational environment is not required until Milestone C. At that time, we will have demonstrated all critical technology elements in the operational environment. Following the Analysis of Alternatives and the Office of the Under Secretary of Defense for Research and Engineering's (OUSD(R&E)) draft Independent Technology Risk Assessment in 2019, the Army conducted three years of additional risk reduction efforts for FLRAA with Joint Multirole technology demonstrators and a competitive demonstration and risk reduction to better understand affordability, technology, and schedule risk. The Army will conduct a formal technology risk assessment prior to MS B, since the program will have a proposed vendor schedule, the winning vendor's design, and integrated master schedule with the recent contract awarded on 5 December 2022.

The Army recommends rewording the recommendation to: "Secretary of the Army, ensure the FLRAA effort plans to demonstrate its critical technologies in accordance with governing DoD policy."

GAO RECOMMENDATION 7: Secretary of the Army, ensure that the FTUAS effort conducts a technology risk assessment prior to contract award for Inc 2.

DA RESPONSE: The Army concurs with the intent of this recommendation and wishes to emphasize that Inc 2 satisfied the requirement for a formal technology risk assessment through demonstration of key technologies, in an operational environment, as part of a one year "Buy, Try, and Inform" risk reduction effort. The FTUAS Inc 2 demonstration included five Brigade Combat Teams (BCTs) and multiple Joint Readiness Training Center and National Training Center rotations. The FTUAS Inc 2 A-CDD does not include critical new technologies that would introduce additional technological risk. Additionally, the competitive down-select strategy of the FTUAS Inc 2 MTA-RP allows for continuous assessment of vendor technology and schedule risks. PM UAS continues to assess, manage, and mitigate acquisition program technology risk throughout the life cycle of the FTUAS Inc 2 program.

The Army recommends rewording the recommendation to: "Secretary of the Army, ensure the FTUAS effort accesses technology risk in accordance with governing DoD policy."

Appendix III: GAO Contact and Staff Acknowledgments

GAO Contact

Jon Ludwigson, (202) 512-4841 or LudwigsonJ@gao.gov

Staff Acknowledgments

In addition to the contact above, J. Kristopher Keener (Assistant Director), Stephen V. Marchesani (Analyst-in-Charge), Jessica M. Berkholtz, Nicholas Pigeon Rossy, Joseph Shir, Pete Anderson, Adam Wolfe, Jennifer Leotta, Emile Etedgui, Mary Weiland, Hai Tran, John Ortiz, Min-Hei (Michelle) Kim, and Alyssa Weir made significant contributions to this review.

Related GAO Products

Other Transaction Agreements: DOD Can Improve Planning for Consortia Awards. [GAO-22-105357](#). Washington, D.C.: September 20, 2022.

GPS Alternatives: DOD Is Developing Navigation Systems But Is Not Measuring Overall Progress. [GAO-22-106010](#). Washington, D.C.: August 5, 2022.

Weapon Systems Annual Assessment: Challenges to Fielding Capabilities Faster Persist. [GAO-22-105230](#). Washington, D.C.: June 8, 2022.

Leading Practices: Agency Acquisition Policies Could Better Implement Key Product Development Principles. [GAO-22-104513](#). Washington, D.C.: March 10, 2022.

Army Modernization: Army Should Improve Use of Alternative Agreements and Approaches by Enhancing Oversight and Communication of Lessons Learned. [GAO-21-8](#). Washington, D.C.: October 1, 2020.

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Technology Readiness Assessment Guide: Best Practices for Evaluating the Readiness of Technology for Use in Acquisition Programs and Projects [Reissued with revisions on Feb. 11, 2020]. [GAO-20-48G](#). Washington, D.C.: January 7, 2020.

DOD Acquisition Reform: Leadership Attention Needed to Effectively Implement Changes to Acquisition Oversight. [GAO-19-439](#). Washington, D.C.: June 5, 2019.

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Schedule Assessment Guide: Best Practices for Project Schedules. [GAO-16-89G](#). Washington, D.C.: December 22, 2015.

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Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes. [GAO/NSIAD-99-162](#). Washington D.C.: July 30, 1999.

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