



## Testimony

Before the Subcommittee on Tactical Air  
and Land Forces, Committee on Armed  
Services, House of Representatives

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# F-35 JOINT STRIKE FIGHTER

## Cost and Schedule Risks in Modernization Program Echo Long-Standing Challenges

Statement of Jon Ludwigson, Director, Contracting and  
National Security Acquisitions

# GAO@100 Highlights

Highlights of [GAO-21-105282](#), a testimony before the Subcommittee on Tactical Air and Land Forces, Committee on Armed Services, House of Representatives

## Why GAO Did This Study

The F-35 Lightning II Joint Strike Fighter program began development in 2001 and remains DOD's most expensive weapon system program. Currently, the program is more than 8 years delayed and \$165 billion over original cost expectations. As the program progresses toward completing operational testing of the aircraft's baseline capabilities, it still faces risks. DOD is also 3 years into an effort, called Block 4, to modernize the F-35 aircraft's capabilities. Block 4 is loosely based on Agile software development processes. With this approach, DOD intends to incrementally develop, test, and deliver small groups of new capabilities every 6 months.

This testimony discusses acquisition-related risks in the F-35 program. It is based largely on findings in GAO's March 2021 and May 2020 annual reports ([GAO-21-226](#); [GAO-20-339](#)) on F-35 acquisition.

## What GAO Recommends

In March 2021, GAO made three recommendations to DOD, including that the F-35 update its Block 4 modernization schedule to reflect achievable time frames. DOD concurred. Since 2001, GAO also made a number of other recommendations to DOD to improve the acquisition of F-35 aircraft. DOD concurred with some of them, but has not yet taken actions to fully implement many of these recommendations.

View [GAO-21-105282](#). For more information, contact Jon Ludwigson at (202) 512-4841 or [ludwigsonj@gao.gov](mailto:ludwigsonj@gao.gov).

July 13, 2021

## F-35 JOINT STRIKE FIGHTER

### Cost and Schedule Risks in Modernization Program Echo Long-Standing Challenges

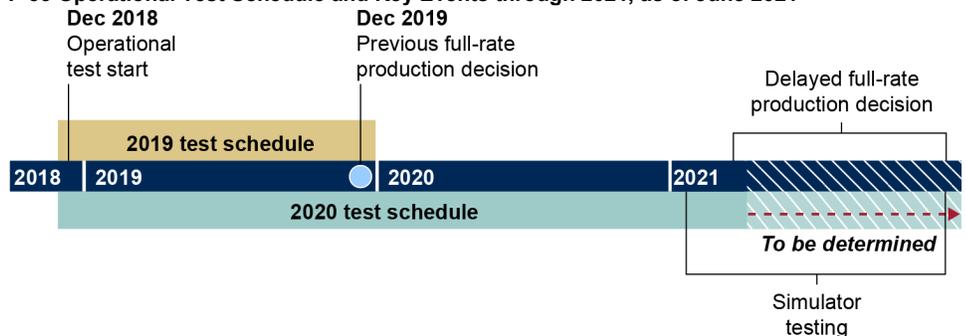
## What GAO Found

While the Department of Defense (DOD) approaches its full-rate production decision point (which would formally authorize DOD's transition from development to full production), the F-35 program is producing nearly 25 percent of the total planned aircraft in low-rate initial production before satisfying the criteria for full-rate production. As it approaches this major milestone, the program has taken steps to but has not fully addressed a number of challenges, even though GAO recommended that it do so, such as the need to:

- resolve critical deficiencies with the aircraft;
- ensure critical manufacturing processes are mature;
- address supply chain issues that strain production and sustainment; and
- take steps to ensure reliability and maintainability goals are met.

Compounding these production issues is the fact that the program has not completed operational testing on the aircraft to ensure warfighters get the capabilities they require, primarily due to increasing delays with the aircraft simulator. In August 2020, the program office determined the simulator—to be used to replicate complex test scenarios that could not be accomplished in real-world environment testing—did not fully represent F-35 capabilities and could not be used for further testing until fixed. Since then, program officials have been developing a new plan to ensure the simulator works as intended. Until this happens, the full-rate production date remains undetermined (see figure).

F-35 Operational Test Schedule and Key Events through 2021, as of June 2021



Source: GAO analysis of Department of Defense data. | [GAO-21-105282](#)

At the same time that the program is resolving risks with the baseline program, DOD is encountering similar cost and schedule increases with its F-35 modernization effort. In the 3 years of Block 4 capability development, the total estimated cost of Block 4 increased from \$10.6 billion to \$14.4 billion. This increase is, in part, a recognition of all costs, past and future, estimated to be required to complete the effort. As GAO recommended in May 2020, DOD now reports all Block 4 costs, not just those associated with the near term. While DOD added another year to the Block 4 schedule, in March 2021 GAO found the remaining development time frame is not achievable. Unless the F-35 program accounts for historical performance in the schedule estimates, the Block 4 schedule will continue to exceed estimated time frames and stakeholders will lack reliable information on when the modernized capabilities will be delivered.

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Chairman Norcross, Ranking Member Hartzler, and Members of the Subcommittee:

Thank you for the opportunity to discuss our work on the F-35 Lightning II Joint Strike Fighter. The F-35 program is a family of fifth-generation strike fighter aircraft that integrates low-observable (stealth) technology with advanced sensors and computer networking capabilities for the U.S. Department of Defense (DOD), as well as seven international partners. The program aims to procure 2,470 F-35s to replace several other aircraft used by the Air Force, Navy, and Marine Corps to perform a wide range of missions. Currently, the program is more than 8 years delayed and \$165 billion over where it originally expected to be at this point. Low-rate initial production began in 2007. To date, the program has delivered over 600 aircraft to the U.S. services, allied partners, and foreign military sales customers.

The DOD is now in the third year of a \$14 billion modernization effort—known as Block 4—to upgrade the hardware and software systems of the F-35. DOD intends for Block 4 to modernize the aircraft and address new threats that emerged since the aircraft's original requirements were established in 2000. DOD uses a development approach for Block 4, referred to as Continuous Capability Development and Delivery (C2D2), loosely based on Agile software development processes. With this approach, DOD intends to incrementally deliver capabilities to the warfighter faster and more frequently than it did during the original development program.

The program wrapped up development of the F-35's original capabilities in 2018 and is undergoing operational testing to verify that the aircraft provides those baseline capabilities before moving into full-rate production. As the program moves toward completing this testing and evaluating the results, it still faces risks ahead of the full-rate production decision. We have previously reported on these and other program risks and made recommendations for improvement. DOD has taken action to address some, but not all, of our recommendations. For a list of our key recommendations and a summary of DOD's actions in response, see appendix I.

This statement discusses (1) the remaining risks with completing operational testing for the baseline program ahead of the full-rate production decision and the steps DOD is taking to mitigate them and (2) DOD's progress in developing and delivering Block 4 modernization capabilities and the program's efforts to address any remaining risks. The

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statement is based on the findings from our reports on F-35 production and modernization issued in May 2020 and March 2021.<sup>1</sup> It also includes some observations from our July 2021 report on F-35 sustainment as well as some updated information on simulator schedule status, weapons testing, deficiencies, and supplier qualification status based on information in DOD's budget request for fiscal year 2022.<sup>2</sup> For the prior reports, we reviewed data provided by the contractors, the program office, and others in DOD and conducted interviews with DOD officials and contractor representatives. For more information on the specific objectives, scope, and methodology for that work, see our prior reports.

The work on which this statement is based was conducted 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.

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## F-35 Testing Delays Led to Postponed Production Milestone

In March 2021, we found that F-35 simulator delays continue to prevent DOD from completing initial operational testing and making a decision to move to full-rate production.<sup>3</sup> The program office postponed a full-rate production decision from the previous plan—sometime between December 2019 and March 2021—to a future unknown date that the program will determine once it knows when the simulator will be operational. As it works toward that production milestone, the program continues to take steps to address ongoing risks such as:

- high overall open deficiencies,
- production delays and quality issues,
- efforts to address Turkey's removal from the supply chain and find new suppliers, and

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<sup>1</sup>GAO, *F-35 Joint Strike Fighter: DOD Needs to Update Modernization Schedule and Improve Data on Software Development*, [GAO-21-226](#) (Washington, D.C.: Mar. 18, 2021) and *F-35 Joint Strike Fighter: Actions Needed to Address Manufacturing and Modernization Risks*, [GAO-20-339](#) (Washington, D.C.: May 12, 2020).

<sup>2</sup>GAO, *F-35 Sustainment: DOD Needs to Cut Billions in Estimated Costs to Achieve Affordability*, [GAO-21-439](#) (Washington, D.C.: July 7, 2021).

<sup>3</sup>[GAO-21-226](#).

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- aircraft not meeting reliability and maintainability goals.

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## Testing Simulator Delays Drive Production Milestone Delay

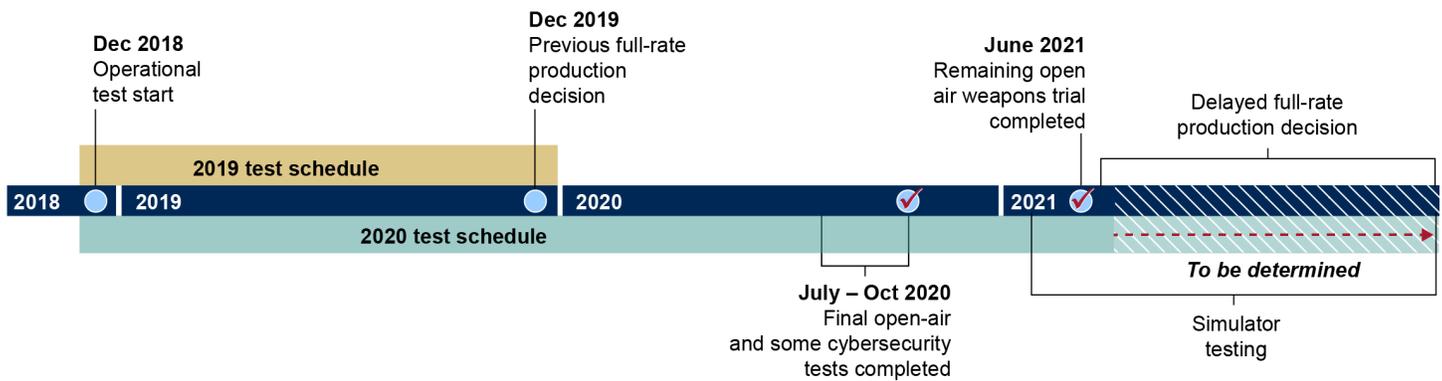
We found that the program continues to delay full-rate production because of lingering issues with completing initial operational testing. After the program's 2012 rebaseline, DOD expected to wrap up initial operational testing in August 2018.<sup>4</sup> However, as of March 2021, it was unclear when that testing will be completed. The program did not complete its planned initial operational testing in 2021 due to delays in developing the F-35 Joint Simulation Environment, which we refer to as the aircraft simulator.<sup>5</sup> The simulator runs the F-35's mission systems software along with other software models (such as other weapons and modern threat systems) to provide complex test scenarios that the program cannot replicate in a real-world environment. While DOD has not set a date to complete the 64 simulated tests required to complete operational testing, the program made progress in other key testing areas. For example, the program completed the four remaining open-air tests in July 2020, the remaining initial operational cybersecurity testing on the logistics system and the aircraft in October 2020, and the final open-air weapons trial in June 2021. Figure 1 shows the test schedule as of June 2021.

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<sup>4</sup>Since 2001, DOD significantly revised the cost and schedule goals for the program three times. DOD initiated the most recent restructuring when the program's cost for each aircraft exceeded critical thresholds. The restructuring process concluded when DOD established a new acquisition program baseline in March 2012 that increased the program's cost estimate by \$162.7 billion and extended delivery schedules 5 to 6 years into the future. This March 2012 revision is the current program baseline, reflecting the cost and schedule estimates to deliver the aircraft and systems and to meet the original program requirements.

<sup>5</sup>The simulator is a compilation of several aircraft, weapons, and environment effects integrated as a simulation, training and test capability.

**Figure 1: F-35 Operational Test Schedules and Key Events through 2021, as of June 2021**



Source: GAO analysis of Department of Defense data. | GAO-21-105282

Testing officials identified technical problems with the simulator in August 2020 and have not established a time frame for fixing those problems, which has delayed the program’s next production milestone decision. In March 2021, we reported that Director, Operational Test and Evaluation (DOT&E) officials told us they were not considering deferring any additional testing or granting a waiver to any test requirements needed for their final report. As a result, the F-35 program office is leading the simulator’s development team in an effort to create a new schedule and to identify what steps must be taken to address the technical issues and ensure that the simulator fully represents F-35 aircraft. The program plans to release an updated simulator test schedule in August 2021, according to a program official.

## Deficiencies Remain High

According to program officials, the F-35 program had 864 open deficiencies as of June 2021, which is slightly lower than the 872 we reported in March 2021. Deficiencies represent specific instances where the weapon system either does not meet requirements or where the safety, suitability, or effectiveness of the weapon system could be affected.

In June 2018, we recommended that the program resolve all critical deficiencies before making a full-rate production decision, in part, to reduce the potential for additional concurrency costs stemming from

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continuing to produce aircraft before testing is complete.<sup>6</sup> DOD concurred with our recommendation and stated that the resolution of critical deficiencies identified during testing will be addressed prior to the full-rate production decision.<sup>7</sup>

Of the 864 open deficiencies, the program characterizes eight as being critical, which is three fewer than we reported in March 2021. According to program officials, at least seven of these critical deficiencies will be resolved prior to the completion of operational testing.

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## Aircraft and Engine Production Challenges Remain

### Fewer Aircraft Delivered; More Were Late and Production Quality Concerns Remain

In 2020, the airframe contractor—Lockheed Martin—delivered fewer aircraft than originally planned, and fewer deliveries than planned are also expected in 2021. In 2020, the airframe contractor delivered 120 aircraft out of the 141 originally on contract and of those 100 were delivered late, which was more than the 17 delivered late in 2019. DOD officials attribute these late deliveries to ongoing issues we have previously reported on, such as fastener quality problems and parts shortages exacerbated by Coronavirus Disease 2019 (COVID-19) workforce restrictions. Program officials stated that Lockheed Martin conducted a supply chain assessment of impact resulting from COVID-19 and identified 37 parts challenges. According to program officials, the contractor does not expect to recover from all of these parts challenges until late 2022. To account for these COVID-19 production challenges, the F-35 program and Lockheed Martin reduced the number of aircraft to be delivered in 2020 from 141 to 124. However, even with this reduced number, Lockheed delivered four fewer aircraft than expected under its revised COVID-19 delivery plan. Furthermore, as of April 2021, the program planned for 158 aircraft deliveries in 2021. However, almost all of the aircraft delivered so far in 2021 have been late, and Lockheed Martin is not projected to deliver all 158 aircraft, according to program officials.

Although production has not met expectations to date, the F-35 program expects to produce a high number of aircraft in 2022. The most aircraft

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<sup>6</sup>GAO, *F-35 Joint Strike Fighter: Development Is Nearly Complete, but Deficiencies Found in Testing Need to Be Resolved*, [GAO-18-321](#) (Washington, D.C.: June 5, 2018).

<sup>7</sup>[GAO-18-321](#).

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the contractors have delivered in one year has been 134, which they accomplished in 2019, before many of the supply chain challenges were present. However, the program now plans for 167 deliveries in 2022, which is more than the contractors have ever delivered and 47 more aircraft, and 39 percent greater, than it delivered in 2020.

In May 2020, we identified concerns with the maturity of Lockheed Martin's production processes.<sup>8</sup> Specifically, we found that only about 3,000 of the over 10,000 airframe contractor's manufacturing key processes met predefined design standards for ensuring product quality. The program is already producing more aircraft during what is referred to as low-rate initial production than originally planned.<sup>9</sup> Statute and DOD policy states that the preliminary low-rate production quantities will be set at the development request for proposal decision point. If, at that time, low-rate initial production quantities are determined to be above 10 percent of the total quantity planned, the Secretary of Defense must explain the reasons for the increase in a report to Congress. When a program reaches the planned low-rate initial production quantity, and will be required to exceed the quantity, the program may seek approval to produce quantities above that amount.<sup>10</sup> According to the F-35 Acquisition Strategy, 610 aircraft are approved for low-rate production, which is nearly 25 percent of the total planned aircraft. This means that almost one-fourth of all aircraft currently anticipated to be purchased are being produced before satisfying the criteria for full-rate production. As we reported in 2020, the manufacturing processes were not meeting metrics for production consistency, indicating that the production processes are not fully mature. We recommended that DOD direct the F-35 program office to evaluate the production risks associated with critical production processes that are not in control and provide that information to Congress ahead of the full-rate production decision.<sup>11</sup> DOD did not concur with our recommendation, but it stated that it would keep the Congress apprised of these matters in its quarterly briefings to the defense committees. As of

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<sup>8</sup>[GAO-20-339](#).

<sup>9</sup>Low-rate initial production establishes the initial production base for the system, provides an efficient ramp-up to full-rate production, and maintains continuity in production pending operational test and evaluation completion.

<sup>10</sup>10 U.S.C. § 2400.

<sup>11</sup>[GAO-20-339](#).

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March 2021, we reported that 15 fewer critical manufacturing processes were in control than we reported in 2020.<sup>12</sup>

We also previously reported on long-standing supply chain challenges, such as late parts or parts shortages.<sup>13</sup> For example, in 2019 we reported that, with the production rate increase, the supply chain was strained to deliver parts on time, which led to parts shortages.<sup>14</sup> We also reported on issues the program faced with managing and moving parts around the world, which limits the warfighter's ability to maintain the aircraft.<sup>15</sup> In 2020, existing supply chain issues were exacerbated by COVID-19. Program officials stated that Lockheed Martin conducted a supply chain assessment of the impact of COVID-19 and identified 37 parts challenges. According to the officials, the contractor does not expect to recover from all of these parts challenges until late 2022. In July 2021, we reported that the F-35 supply chain had become more responsive but that the F-35 program was still not meeting its objectives.<sup>16</sup>

Despite the delays to aircraft deliveries and supply chain issues, other production metrics associated with the airframe slightly improved in 2020. Aircraft take less time to build, on average, and the contractor spends less time on scrap, rework, and repair.

#### Engine Deliveries Late Due to Quality Issues and Supplier Delays

In 2020, the engine contractor—Pratt & Whitney—continued to deliver fewer F-35 engines on time, which Defense Contract Management Agency officials attribute to production quality issues and parts delays. According to Lockheed Martin representatives, late delivery of these engines did not affect the aircraft delivery schedule because Pratt & Whitney builds time into its schedule to deliver the engines earlier than they are actually needed for production. As of November 2020, Pratt & Whitney had delivered 115 of 136 engines late. DOD officials stated the

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<sup>12</sup>[GAO-21-226](#).

<sup>13</sup>[GAO-20-339](#); and GAO, *F-35 Joint Strike Fighter: Action Needed to Improve Reliability and Prepare for Modernization Efforts*, [GAO-19-341](#) (Washington, D.C.: Apr. 29, 2019).

<sup>14</sup>[GAO-19-341](#).

<sup>15</sup>Within the F-35 program, U.S. services share access to spare parts along with the rest of the global fleet in the global spares pool. GAO, *F-35 Aircraft Sustainment: DOD Needs to Address Substantial Supply Chain Challenges*, [GAO-19-321](#) (Washington, D.C.: Apr. 25, 2019).

<sup>16</sup>[GAO-21-439](#).

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two main issues that affected late delivery of engines are increased demand for engine parts from fielded aircraft for flaps and seals due to coating loss and COVID-19-related effects at various suppliers.<sup>17</sup>

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## Program Continues Its Efforts to Replace Turkish Suppliers

The program continues to address supplier challenges associated with the removal of Turkey from the supply chain and identified new suppliers for 1,005 parts produced in Turkey. In July 2019, DOD removed Turkey from the F-35 program due to its government's decision to procure Russian-made radar systems. The Under Secretary of Defense for Acquisition and Sustainment directed that the F-35 program establish alternative sources and stop placing orders with Turkish suppliers after March 2020.

We reported in May 2020 that Turkey's removal from the F-35 program was likely to compound existing supply chain issues.<sup>18</sup> To mitigate those concerns, the Under Secretary of Defense for Acquisition and Sustainment stated the F-35 program is authorized to continue accepting delivery of parts from Turkish suppliers through the end of lot 14 deliveries (scheduled to take place through 2022). In May 2020, we recommended that DOD direct the F-35 program office to evaluate supplier readiness—particularly for those replacing Turkish suppliers—along with the steps it is taking to address those risks and provide this information to Congress ahead of the full-rate production decision. DOD did not concur with our recommendation, but it stated that it would keep Congress apprised of these matters in its quarterly briefings to the defense committees.

As of May 2021, the program identified alternative suppliers for all 1,005 parts. According to program officials, all of the 817 air vehicle parts and 145 of the 188 engine parts are qualified.<sup>19</sup> The program estimates it will cost \$108 million to establish alternative suppliers but has not negotiated these costs and, therefore, does not yet know what the cost impact will be for the parts being produced.

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<sup>17</sup>According to Pratt & Whitney representatives, the protective coating on flaps and seals—specific parts of the engine—wears away faster than new parts can be produced. Pratt & Whitney representatives stated they plan to increase the capacity and capability of the supplier and to implement a more durable coating—one that will last the life of the part—to help mitigate this issue.

<sup>18</sup>[GAO-20-339](#).

<sup>19</sup>According to program officials, new suppliers are required to go through qualification and testing to ensure the design integrity for their parts.

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## Reliability and Maintainability Is Improving but Not All Goals Are Met and Affordability Remains a Concern

We found that F-35 reliability and maintainability performance continues to improve, but the program is still not meeting all of its performance goals. The reliability and maintainability goals lay out specific quantitative metrics aimed at ensuring that an aircraft will be available for operations as opposed to out-of-service for maintenance. In April 2019, we found that the program was only meeting about half of its 24 reliability and maintainability goals. We also found that it was unlikely that the aircraft would meet their reliability and maintainability goals by the time they reached maturity.<sup>20</sup> We made five recommendations, including that the program office take steps to ensure those goals are met by aircraft maturity or revise those goals to be more achievable.<sup>21</sup> DOD concurred with our recommendations and has improved F-35 reliability and maintainability since then. As of June 2020, the program was meeting or close to meeting 17 of its 24 goals.

Program officials attribute improvements in meeting seven more reliability and maintainability metrics in 2020 to their efforts to fund and implement reliability improvement projects over the last year. Program officials stated that they increased funding from \$7 million in 2019 to \$40 million in 2020 and implemented 51 new reliability and maintainability improvement projects. Although the program is still not meeting seven of its 24 reliability and maintainability goals, measurable improvements in these goals can take time to manifest. For example, fielded aircraft must be modified and flown for many hours before the program can measure performance and implement further improvements, if needed.

While there have been recent improvements in reliability and maintainability metrics, affordability of the aircraft remains a major concern. We have previously reported on the F-35 program's rising estimated sustainment costs and challenges maintaining an expanding fleet. In July 2021, we reported that the military services face a substantial and growing gap between estimated sustainment costs and affordability constraints—i.e., costs per tail (aircraft) per year that the services project they can afford—totaling about \$6 billion in 2036 alone.<sup>22</sup>

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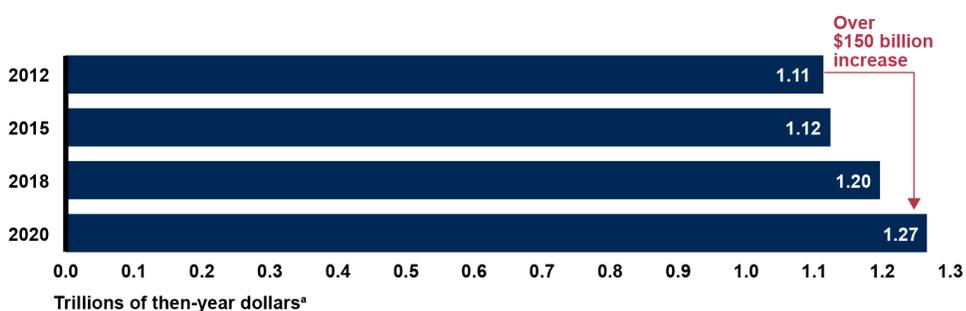
<sup>20</sup>The F-35 aircraft reach maturity when all variants have flown a combined 200,000 hours, with each variant flying at least 50,000 hours. The F-35A reached its planned maturity in July 2018 but is still not meeting four of its eight metrics. The F-35B and C variants have more time to meet their metrics before they reach their planned maturity in 2021 and 2024 respectively.

<sup>21</sup>[GAO-19-341](#).

<sup>22</sup>[GAO-21-439](#).

The services will collectively be confronted with tens of billions of dollars in sustainment costs that they project as unaffordable during the life cycle of the program. We also noted that estimated F-35 life-cycle sustainment costs increased by over \$150 billion from fiscal years 2012 through 2020, as shown in figure 2.

**Figure 2: Growth in F-35 Life-Cycle Sustainment Cost Estimates**



Source: GAO analysis of Department of Defense data. | GAO-21-105282

<sup>a</sup>Then-year dollars include the effects of inflation.

Cost reductions become increasingly difficult as the program grows and matures. However, we found there is no agreed-upon approach to control the costs. In July 2021, we recommended that DOD assess and document its ability to meet the services' affordability constraints with existing or planned cost-reduction efforts and also assess and document changes in service-related program requirements (e.g., the number of aircraft purchases and flying hours) to achieve cost reductions.<sup>23</sup> Additionally, we recommended that DOD develop and document a program-wide plan for achieving the services' affordability constraints and that it also develop and document a risk management approach for addressing potential challenges to achieving affordability. DOD partially concurred with our recommendations and identified actions it is currently or planning to take to address them. Further, we suggested that Congress consider (1) requiring DOD to report annually on progress made in achieving the services' affordability constraints, including the actions taken and planned to reduce sustainment costs; and (2) making future F-

<sup>23</sup>[GAO-21-439](#)

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35 aircraft procurement decisions contingent on DOD's progress in achieving its F-35 sustainment affordability constraints.<sup>24</sup>

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## Modernization Cost Estimates Are Increasing and Remaining Schedule Is Not Achievable

In March 2021, we found the F-35 program continues to experience development cost increases and schedule expansion.<sup>25</sup> Costs continued to rise during 2020 due to delays in schedule and challenges in developing certain technologies, among other things. In 2020, the program added a year to its Block 4 modernization schedule and now expects to extend Block 4 development into fiscal year 2027. In March 2021, we found that the schedule was not based on the contractor's demonstrated past performance but on estimates formulated at the start of the Block 4 effort, increasing the likelihood that the scheduled 2027 completion date is not achievable. In addition, the program office plans to require new metrics that should improve insight into Block 4 capability delivery and ongoing discovery of software defects.

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## Block 4 Development Costs Continue to Increase, Schedule Continues to Expand, and Underlying Cost Estimate Does Not Fully Reflect Leading Practices

The estimated cost for Block 4 development increased and the schedule expanded every year since the program started the development effort in 2018. In May 2020, we found that DOD's Block 4 reports to Congress did not fully represent the total estimated costs of Block 4 development.<sup>26</sup> DOD focused its reporting on the future year defense program and excluded costs incurred prior to 2018 and after 2024. For example, in 2018, DOD reported that Block 4 development would cost \$10.6 billion for fiscal years 2018 through 2024. We recommended that the program office provide a more holistic perspective of the total Block 4 development costs to provide Congress with improved oversight of Block 4 costs.<sup>27</sup> In response to our recommendation, DOD reported to Congress that the program's total cost of \$14.4 billion reflects not only earlier incurred costs but also an additional 3 years of Block 4 development for fiscal years 2013 through 2027. Figure 3 shows the increases in Block 4 development time frames and estimated costs.

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<sup>24</sup>[GAO-21-439](#).

<sup>25</sup>[GAO-21-226](#).

<sup>26</sup>These reports are required by the National Defense Authorization Act for Fiscal Year 2017, Pub. L. No. 114-328, § 224(d), (2016).

<sup>27</sup>[GAO-20-339](#).

**Figure 3: Block 4 Development Cost and Schedule Growth Since 2018 (fiscal year dollars in billions)**



Source: GAO analysis of Department of Defense data. | GAO-21-105282

Note: The 2018 and 2019 estimates reflect a shorter time frame as DOD focused its estimates on the future year's defense program, which is DOD's projected spending for the current budget year and at least the next 4 years. The 2020 estimate includes costs for the entirety of the program, including all prior years' actual costs and the 3 additional years estimated to completion from the original 2018 estimate.

We found that the Block 4 development cost estimate increased by \$3.5 billion since DOD's May 2019 Block 4 report to Congress. Over half of that increase—\$1.9 billion—was cost growth within various aspects of the Block 4 development program. For example, Technology Refresh 3 (TR-3)—a critical enabler of Block 4 capabilities—costs continued to grow. According to program officials, much of the increase in TR-3 costs was because its development is more complex than originally expected.

Furthermore, in May 2020 we found that the F-35 Block 4 cost estimate used to prepare its report to Congress was missing key elements of GAO cost estimate leading practices, such as taking into account risk and uncertainty.<sup>28</sup> We recommended that the program office address these elements in the next update to its Block 4 cost estimate. DOD did not fully concur with these recommendations but stated it would take steps to improve future estimates.

### Planned Block 4 Development Schedule Is Not Achievable

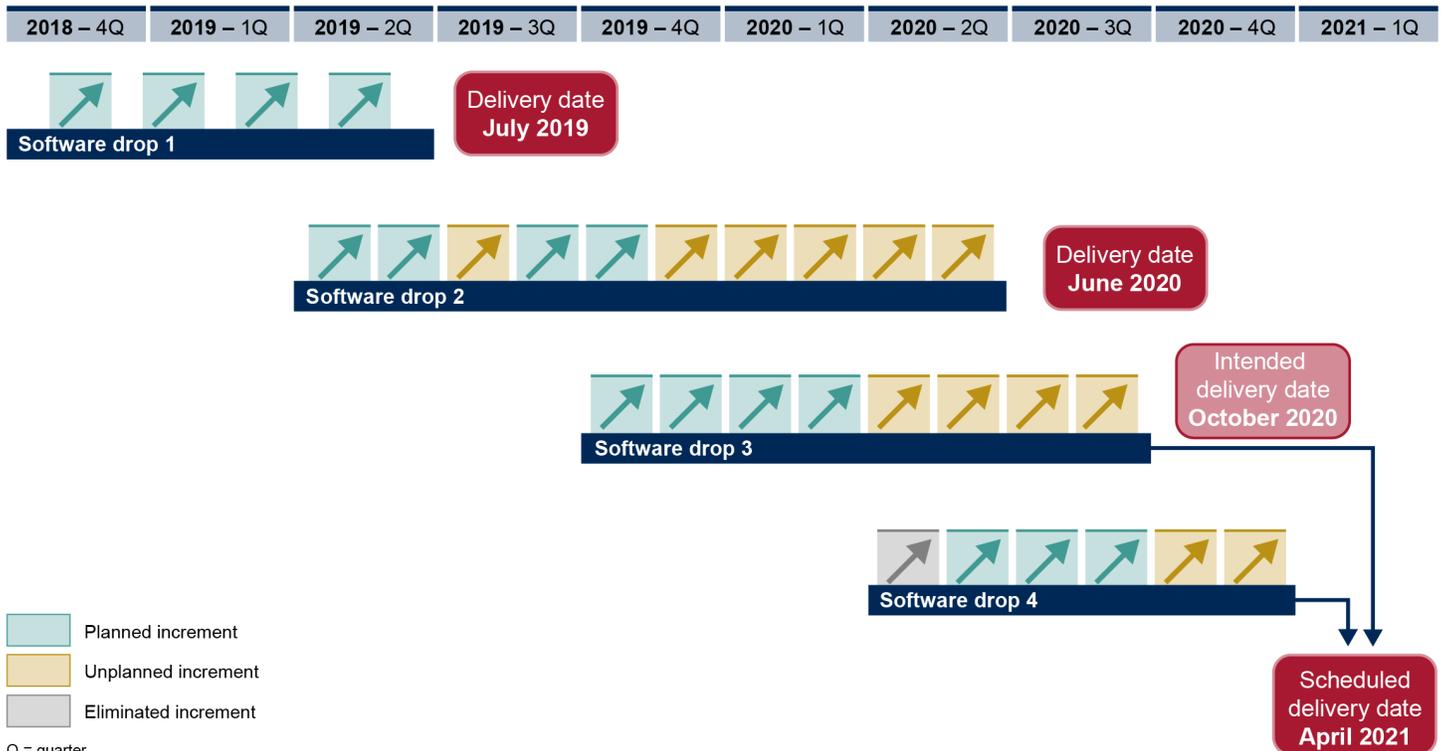
The F-35 program is more than 3 years into Block 4 development, but it has not delivered new capabilities as planned. Further, we found in March 2021 that the remaining development schedule is not based on the most recent data available and is not achievable. Under the Continuous

<sup>28</sup>[GAO-20-339](#).

Capability Development and Delivery (C2D2) development approach, the F-35 program office plans to incrementally develop, test, and deliver smaller groups of capabilities to the F-35 fleet—delivered aircraft that are operating around the world—every 6 months.

Under the C2D2 approach, Lockheed Martin is to sequentially develop four software increments on the way to each 6-month software drop. These increments are intended to refine and further develop capabilities over time as each is tested by the developmental test fleet. While the program generally plans for these four increments per software drop, over the last 2 years, we found that some software drops required more increments and took longer to develop than planned, as shown in figure 4. These additional increments delayed delivery of capabilities.

**Figure 4: Actual Software Increments Exceed Number of Planned Increments**



Source: GAO analysis of Department of Defense data. | GAO-21-105282

We found that the more recent drops, in particular, have more increments beyond the planned four. For example, software delivered in June 2020

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included 10 increments—six more than originally planned. Furthermore, the planned October 2020 software drop included eight increments—four more than planned. Lockheed Martin representatives told us that each of these added increments was to address software defects.

Including all capabilities in the first increment of a software drop provides the contractor more time to find and, as needed, address any defects before the software is fielded to the fleet. Ideally, according to the program office, the contractor would identify defects in the software lab or before the software is fielded to the developmental test aircraft. However, a November 2020 analysis conducted by a consulting firm on behalf of the program office found that between December 2017 and September 2020, 656 software defects (or 23 percent of all software defects) were identified after the software was delivered to the test aircraft. Discovering these defects late contributed to the need for additional, unplanned software increments to fix those defects.

In addition, we found that the program office had not adjusted its schedule to reflect the unplanned increments and delivery delays because it has maintained the desire to deliver software every 6 months. According to the GAO Agile Assessment Guide, a program's schedule should realistically reflect how long each activity will take and software development teams should examine historical performance to inform future estimates.<sup>29</sup> Program officials stated that, while the program revised its schedule to deliver capabilities later than initially planned, they had not formulated a revised schedule for delivery of future capabilities based on the contractor's demonstrated past performance.

Program officials stated that the program is currently reviewing the feasibility of its schedule. Without a software development schedule that reflects how much work can be accomplished in each increment based on historical performance, the program office will continue to experience Block 4 development delays, and capabilities will continue to be postponed into later software drops. Delays in capability development and delivery increase the risk that capabilities will be out of date by the time they are delivered, capability development costs will be higher, and capabilities will be delivered to the fleet with deficiencies. Ultimately, these delays lead to warfighters waiting longer for the capabilities they need to achieve their missions.

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<sup>29</sup>[GAO-20-590G](#).

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To address these issues, in March 2021, we recommended that DOD ensure that the F-35 program office updates its Block 4 schedule to reflect historical performance and develop more achievable time frames for Block 4 modernization capability development and delivery. DOD concurred with this recommendation and identified actions it was taking to address it.

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## Program Office Is Adding New Metrics to Measure Software Quality

In March 2021, we found the Block 4 contract requires the contractor to report data on metrics for software quality, performance, cost, schedule, and staffing to the F-35 program that inform software development.<sup>30</sup> However, these metrics provide limited insight into aspects of software development quality under the Agile software development approach.<sup>31</sup> Our *Agile Assessment Guide*, which identifies key practices for Agile software development, states that clear, meaningful, actionable metrics provide managers information to measure program performance.<sup>32</sup> The F-35 program established the initial metrics the contractor is required to report on in its November 2018 contract. Program officials told us that Block 4 development activities, at that time, were focused on resolving deficiencies from the baseline program, rather than on developing new capabilities, which influenced the metrics in the contract.

Since the November 2018 contract award, program officials explained that, as they transitioned to developing new capabilities, they recognized the need for more information and took steps to collect other metrics on software development. For example, as we reported in March 2021, the program office worked with the contractor to obtain data on 19 metrics, in addition to those required by contract, to provide further insight into the quality and performance of software development. Despite these additions, program officials acknowledged that they are not collecting all the metrics they need to better understand program risks and make more informed management decisions, but are taking steps to do so. Program officials explained that they are using guidance provided by DOD and coordinating with other program offices that have used Agile software development to identify more informative Agile software development metrics.

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<sup>30</sup>[GAO-21-226](#).

<sup>31</sup>[GAO-21-226](#). The F-35 program uses a new Agile-like development approach for its Block 4 software development effort and relies on software development metrics collected and reported by Lockheed Martin to monitor its software development progress.

<sup>32</sup>[GAO-20-590G](#).

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In March 2021, we made two recommendations aimed at improving the program's insight into the quality of software the contractor is developing, and DOD concurred with our recommendations. Program officials stated that the next iteration of the Block 4 contract, expected to be awarded in December 2021, will require new metrics that should provide better insight into on-time delivery of capabilities and software defects, two key issues hindering the program from adhering to its development schedule.

In conclusion, the F-35 is expected to serve key roles in U.S. and allied air fleets for years to come. While the program approaches its full-rate production decision point, the program is producing nearly 25 percent of the total planned aircraft in low-rate initial production before satisfying the criteria for full-rate production and with processes that are not fully mature. Nonetheless, a concerning number of challenges remain in the baseline program. Each year DOD plans to procure an increasing number of aircraft, despite manufacturing processes that are not fully mature, supply chain issues that strain production and sustainment, and a number of critical deficiencies with the aircraft. Compounding these production issues, the program has not completed testing on the baseline aircraft to ensure warfighters get the capabilities they require, primarily due to prolonged delays with completing the simulator. At the same time, the program is more than 3 years into modernizing the aircraft and is encountering similar issues as experienced in the baseline program, namely cost and schedule increases.

Looking ahead, the gap between projected sustainment costs and what the services say they can afford is already on track to widen substantially. The myriad challenges with the F-35 confound U.S. efforts to modernize its high-end tactical jet fleet to face near-peer adversaries and modern threats. Additionally, the challenges remaining in the manufacturing, supply chain, testing, and late delivery of baseline aircraft, together with the affordability and sustainment challenges, highlight the importance of having a realistic expectation of how many aircraft the contractor can produce on-time in the near-term. All of these challenges raise the importance of continued congressional oversight of the program.

Chairman Norcross, Ranking Member Hartzler, and Members of the Subcommittee, this completes my prepared statement. I would be pleased to respond to any questions you may have. We look forward to continuing to work with the Congress as we to continue to monitor and report on the progress of the F-35 program.

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## GAO Contact and Staff Acknowledgments

If you or your staff have any questions about this testimony, please contact Jon Ludwigson at (202) 512-4841 or [ludwigsonj@gao.gov](mailto:ludwigsonj@gao.gov). Contact points for our Office of Congressional Relations and Public Affairs may be found on the last page of this statement.

GAO staff who made key contributions to this testimony are Justin Jaynes (Assistant Director), Jillena Roberts (Analyst in Charge), Gioia Chaouch, Laura Greifner, Roxanna Sun, and Lauren Wright. Other staff who made key contributions to the reports cited in the testimony are identified in the source products.

# Appendix I: Prior GAO Reports on the F-35 Acquisition Program and Department of Defense Actions

**Table 1: Prior GAO Reports on F-35 Lightning II Joint Strike Fighter and Department of Defense (DOD) Responses**

<b>Year, GAO report</b>	<b>Primary GAO conclusions and recommendations</b>	<b>DOD response and actions</b>
2001 <a href="#">GAO-02-39</a>	Critical technologies needed for key aircraft performance elements are not mature. We recommended that the program delay start of system development until critical technologies are matured to acceptable levels.	DOD did not concur with our recommendation. DOD did not delay the start of system development and demonstration stating technologies were at acceptable maturity levels and that it will manage risks in development.
2006 <a href="#">GAO-06-356</a>	The program was entering production with less than 1 percent of testing complete. We recommended that the program delay investing in production until flight testing shows that the Joint Strike Fighter performs as expected.	DOD partially concurred but did not delay start of production because it believed the risk level was appropriate.
2010 <a href="#">GAO-10-382</a>	Costs and schedule delays inhibited the program's ability to meet needs on time. We recommended that the program complete a comprehensive cost estimate and assess warfighter and initial operational capability requirements. We suggested that Congress require DOD to tie annual procurement requests to demonstrated progress.	DOD continued restructuring, increasing test resources, and lowering the production rate. Independent review teams evaluated aircraft and engine manufacturing processes. Cost increases later resulted in a Nunn-McCurdy breach. Military services completed the review of capability requirements, as we recommended.
2014 <a href="#">GAO-14-322</a>	Delays in developmental flight testing of the F-35's critical software may hinder delivery of the warfighting capabilities to the military services. We recommended that DOD conduct an assessment of the specific capabilities that can be delivered and those that will not likely be delivered to each of the services by their established initial operational capability dates.	DOD concurred with our recommendation. On June 22, 2015, the Under Secretary of Defense for Acquisition, Technology, and Logistics issued a Joint Strike Fighter software development report, which met the intent of our recommendation.
2016 <a href="#">GAO-16-390</a>	The terms and conditions of the planned block buy and managing follow-on modernization under the current baseline could present oversight challenges for Congress. We recommended that the Secretary of Defense hold a milestone B review and manage follow-on modernization as a separate major defense acquisition program.	DOD did not concur with our recommendation. DOD viewed modernization as a continuation of the existing program and the existing oversight mechanisms, including regularly scheduled high-level acquisition reviews, would be used to manage the effort.

Year, GAO report	Primary GAO conclusions and recommendations	DOD response and actions
2017 <a href="#">GAO-17-351</a>	Program officials projected that the program would only need \$576.2 million in fiscal year 2018 to complete baseline development. At the same time, program officials expected that more than \$1.2 billion could be needed to commit to Block 4 and economic order quantity in fiscal year 2018. GAO recommended DOD use historical data to reassess the cost of completing development of Block 3F, complete Block 3F testing before soliciting contractor proposals for Block 4 development, and identify for Congress the cost and benefits associated with procuring economic order quantities of parts.	DOD did not concur with the first two recommendations and partially concurred with the third while stating that it had finalized the details of DOD and contractor investments associated with an economic order quantity purchase and would brief Congress on the details, including costs and benefits of the finalized economic order quantity approach.
2018 <a href="#">GAO-18-321</a>	The program office plans to resolve a number of critical deficiencies after full-rate production. We recommended that the F-35 program office resolve all critical deficiencies before making a full-rate production decision and identify steps needed to ensure the F-35 meets reliability and maintainability requirements before each variant reaches maturity. We also suggested that Congress consider providing in future appropriations that no funds shall be available for obligation for F-35 Block 4 until DOD provides a report setting forth its complete acquisition program baseline for the Block 4 effort to the congressional defense committees.	DOD concurred with both recommendations and identified actions that it would take in response. The National Defense Authorization Act for Fiscal Year 2019 included a provision limiting DOD from obligating or expending more than 75 percent of the appropriations authorized under the Act for the F-35 continuous capability development and delivery program until 15 days after the Secretary of Defense submits to the congressional defense committees a detailed cost estimate and baseline schedule. DOD submitted its F-35 Block 4 report to Congress in May 2019, which contained cost and schedule information responding to this provision.
2019 <a href="#">GAO-19-341</a>	We recommended that the Secretary of Defense ensure that the F-35 program office assess the feasibility of its required reliability and maintainability targets, identify specific and measurable reliability and maintainability objectives in its improvement plan guidance, document projects that will achieve these objectives, and prioritize funding for these improvements. We also recommended that the Secretary of Defense ensure that the F-35 program office completes its business case for the initial Block 4 capabilities under development before initiating additional development work.	DOD concurred with our four recommendations on reliability and maintainability and identified actions it would take in response. While DOD has taken some action, these recommendations are still open. DOD did not concur with our recommendation on Block 4 modernization. DOD stated that the F-35 program has adequate cost, schedule, and technical maturity knowledge to begin the development of initial Block 4 capabilities.
2020 <a href="#">GAO-20-339</a>	We suggested that Congress extend DOD's Block 4 modernization reporting requirement beyond 2023 to extend to the end of the effort. We also made five recommendations to the Secretary of Defense to submit production risks to Congress prior to full-rate production, to establish a Block 4 cost estimate baseline that covers all costs, and to take other steps to improve the Block 4 cost estimate. These steps are to complete a work breakdown structure, conduct a risk and uncertainty analysis, and consider technology risk assessments to help inform the Block 4 development cost estimate.	While DOD did not concur with two of our recommendations—including to evaluate production risks and update its Block 4 cost estimate with a program-level plan—it identified actions that, if implemented, will meet the intent of these recommendations. DOD concurred with our three other recommendations.

Year, GAO report	Primary GAO conclusions and recommendations	DOD response and actions
2021 <a href="#">GAO-21-226</a>	We recommended that the Secretary of Defense direct the F-35 program office to update its Block 4 schedule to reflect historical performance, to develop more achievable time frames for Block 4 modernization capability development and delivery, and to provide an accurate baseline for comparing future cost estimates. We also recommended that the F-35 program office identify and implement automated tools to enable access to real-time data for software development metrics and set software performance target values for critical software quality metrics.	DOD concurred with all three recommendations and identified actions it was taking to address them.
2021 <a href="#">GAO-21-439</a>	We suggested that Congress consider requiring the Under Secretary of Defense for Acquisition and Sustainment report annually on progress in achieving the services' affordability constraints and consider making future F-35 aircraft procurement decisions contingent on DOD's progress in achieving F-35 sustainment affordability constraints. We also made 4 recommendations to the Secretary of Defense to ensure that, prior to the milestone C decision, document DOD's ability to meet the services' affordability constraints, changes in service-related program requirements, a program-wide plan for achieving affordability constraints, and a risk-management approach for addressing potential challenges to achieve affordability objectives.	DOD partially concurred with the four recommendations. DOD agreed with the substance of all four of our recommendations and identified actions it is currently or planning to take to address them. However, for each of the recommendations, DOD stated that it was uncertain if it could address the recommendation prior to a milestone C decision for the program.

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