



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 Growth and Schedule Delays Continue

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

Accessible Version

GAO Highlight

Highlights of [GAO-22-105943](#), 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 remains DOD's most expensive weapon system program. It is estimated to cost over \$1.7 trillion to buy, operate, and sustain. DOD plans to acquire 2,470 F-35s to replace several other aircraft used by the Air Force, Navy, and Marine Corps. As of November 2021, the program has delivered over 700 aircraft of the 3,360 currently planned for the U.S. services, allied partners, and foreign military sales customers.

This testimony discusses acquisition-related risks in the F-35 baseline program and modernization effort. It is largely based on GAO's April 2022 report ([GAO-22-105128](#)) on F-35 acquisition.

What GAO Recommends

Since 2001, GAO has made 46 recommendations across 18 reports aimed at improving the acquisition of the F-35 aircraft. DOD has agreed with many of these recommendations and taken action to address some but not all of them. Among those recommendations that have not yet been implemented are several focused on addressing continuing cost growth and schedule delays in DOD's upgrades of F-35 hardware and software systems.

View [GAO-22-105943](#). For more information, contact Jon Ludwigson at (202) 512-4841 or ludwigsonj@gao.gov.

April 27, 2022

F-35 JOINT STRIKE FIGHTER

Cost Growth and Schedule Delays Continue

What GAO Found

The Department of Defense (DOD) has not yet authorized the F-35 program to begin full-rate production, which is now more than 10 years later than originally planned. Full-rate production generally is the point when a program has demonstrated an acceptable level of performance and reliability and, in the case of the F-35, is ready for higher manufacturing rates. The delay in reaching this milestone stems largely from problems developing the F-35 simulator. The simulator is needed to conduct key tests prior to making a full-rate production decision. DOD is currently reassessing when it will make this decision.

Although the program will not update the simulator schedule until later this spring, DOD plans to acquire up to 152 aircraft per year. At that rate, DOD would purchase about one-third of all planned F-35 aircraft before validating that the aircraft meets requirements. Further, if more performance issues are identified, fixing aircraft later will cost more than resolving issues before production.

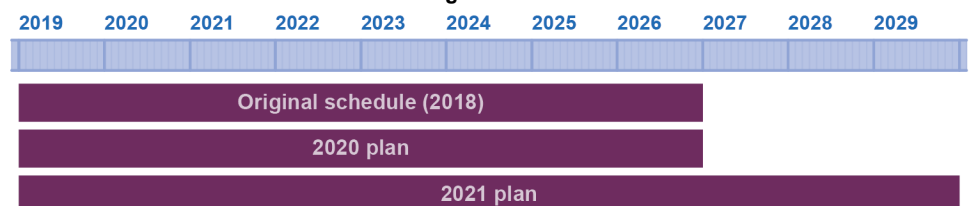
F-35B Exercising Its Vertical Landing Capability



Source: Lockheed Martin Corporation (All rights reserved). | GAO-22-105943

DOD is also 4 years into development of its modernization effort, known as Block 4, which continues to experience cost growth and schedule delays. DOD intends for Block 4 development efforts to upgrade F-35 hardware and software systems. Block 4 costs continued to rise during 2021 due to higher hardware upgrade costs, among other things. The program office extended Block 4 development and delivery into fiscal year 2029—3 years beyond the original plan (see figure).

F-35 Block 4 Modernization Schedule Changes since 2018 Plan



Source: GAO analysis of Department of Defense data. | GAO-22-105943

To avoid further delays, the program office recently began taking steps to improve the timeliness and quality of software deliveries. Effective implementation of these steps and GAO's prior Block 4 recommendations can lead to improved modernization outcomes.

April 27, 2022

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. The F-35 will be used by the Department of Defense (DOD), as well as seven international partners, to perform a wide range of missions. DOD aims to procure a total of 2,470 F-35s to replace several other aircraft used by the Air Force, Navy, and Marine Corps. To date, the program has delivered over 700 aircraft to the U.S. services, international partners, and foreign military sales customers. The program, however, is also more than a decade delayed and \$165 billion over its original plans.

DOD is now in the fourth year of a \$15 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). This approach is loosely based on Agile software development processes.¹ 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 completed development of the F-35’s original capabilities in 2018 and is undergoing initial operational testing to verify that the aircraft provides those baseline capabilities before obtaining approval to begin 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. Full-rate production generally is the point when a program has demonstrated an acceptable level of performance and reliability, and, in the case of the F-35, is ready for higher manufacturing rates.

¹Agile is a framework for incremental development, which has been adopted by many federal agencies. Agile emphasizes development of software in iterations that are continuously evaluated on their functionality, quality, and customer satisfaction.

We have previously reported on these and other program risks and made 46 recommendations for improvement. In recent years, DOD generally agreed with our recommendations and has taken action to address some, but not all, of them. Eight recommendations remain open. For selected prior reports with key findings and recommendations over the last 21 years, as well as DOD's actions in response, see appendix I.²

This statement discusses (1) the remaining risks with completing the original development program as it progresses towards the full-rate production decision; and (2) DOD's progress in developing and delivering Block 4 modernization capabilities and the program's efforts to address any remaining risks. The statement is based on the results of our report on F-35 production and modernization issued earlier this week as well as prior related reports.³ For those reports, in general, we analyzed data provided by the contractors, the program office, and others in DOD and conducted interviews with DOD officials and contractor representatives. Each of the reports provides further information on specific objectives, scope, and methodology. In addition, we summarize information from our prior reports, including relevant recommendations and the actions taken by DOD to address them, where appropriate in this statement.

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.

F-35 Simulator and Testing Delays Continue to Postpone Production Milestone

F-35 simulator delays continue to prevent DOD from completing initial operational test and evaluation.⁴ Despite these delays, the program is

²The full range of prior reports and a detailed description of the status of each recommendation is available on our website at www.gao.gov.

³GAO- F-35 *Joint Strike Fighter: Cost Growth and Schedule Delays Continue*, [GAO-22-105128](https://www.gao.gov/products/GAO-22-105128) (Washington, D.C.; Apr. 25, 2022).

⁴[GAO-22-105128](https://www.gao.gov/products/GAO-22-105128).

generally acquiring an increasing number of aircraft each year, increasing the risks of higher costs to fix those aircraft if issues are discovered. Further, the F-35 program modified its delivery schedule to accommodate supply chain challenges and delays due to the COVID-19 pandemic, contractors continue to deliver airframes and engines late and with quality issues.

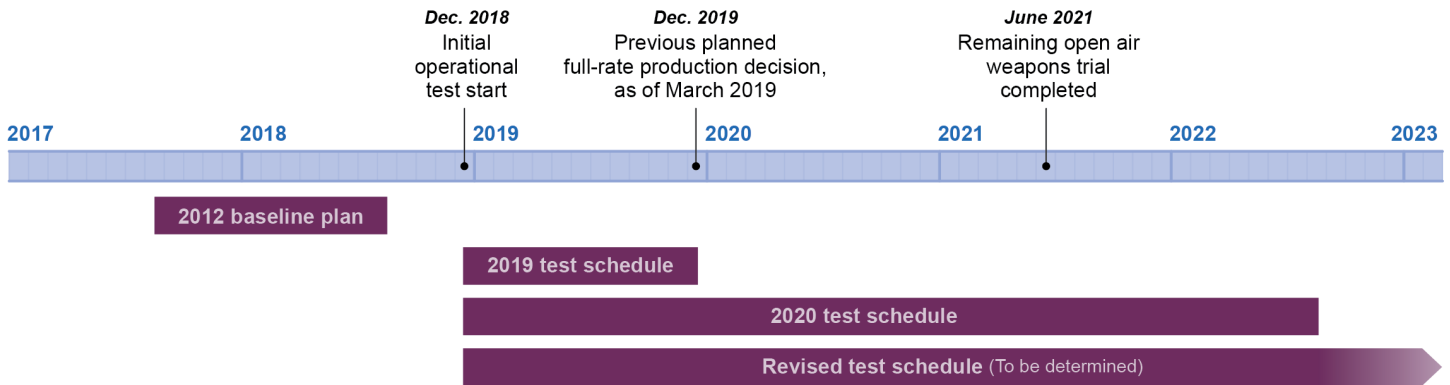
Simulator Delays and Deficiencies Continue to Prevent Completion of Operational Testing

The program office has delayed completion of initial operational test and evaluation to an undetermined date because of challenges developing the Joint Simulation Environment, which we refer to as the simulator. 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 a simulated environment for conducting complex test scenarios that cannot be replicated in a real-world environment. The program office completed the final remaining open-air weapons test in June 2021 but needs to complete 64 simulated tests before initial operational testing will be finished. Initial operational testing is aimed at validating that the aircraft and its systems meet the requirements initially established for the F-35 program, particularly the remaining 64 simulated test flights. The simulator must be fully developed before DOD can conduct these 64 test trials.

We reported in April 2019 that the simulator's development was behind schedule and was a risk to operational testing.⁵ Since then, the program has struggled to develop the complex software and functionality needed to complete the simulator. The difficulties stem, in part, from the program office's original plan to have the contractor, Lockheed Martin, develop the simulator. However, in August 2017, program office officials decided that the contractor's proposal was too expensive. As a result, the program decided to have the Navy complete the work. Since then, the Navy has experienced a number of technical challenges with completing the development of the simulator, leading to more delays. These delays led the program to postpone completion of initial operational testing multiple times, and it has yet to finalize its testing schedule, as shown in figure 1.

⁵GAO- F-35 *Joint Strike Fighter: Action Needed to Improve Reliability and Prepare for Modernization Efforts*, [GAO-19-341](#) (Washington, D.C.: Apr. 29, 2019).

Figure 1: F-35 Initial Operational Test and Evaluation Schedule Is Not Yet Determined



Source: GAO analysis of Department of Defense data. | GAO-22-105943

As of January 2022, the program had not developed a new estimated date for completing the simulator. Program officials told us that they will release the revised simulator development schedule when a new acquisition program baseline is approved, the date of which has yet to be determined. The acquisition program baseline is, in essence, a full program business case that includes cost, schedule, and performance information.

The program office has not yet committed to the remaining simulator development schedule, in part, because it continues to find technical issues with the simulator. Since our March 2021 report, DOD has continued to identify and correct technical issues with the simulator, which could lead to additional schedule delays. As of December 2021, there were 54 simulator technical issues, 32 of which the program has determined it must fix and verify before beginning to use the simulator. Program officials stated that, as those issues are resolved, additional technical issues with the simulator may be discovered, which could lead to more schedule delays.

Producing Large Numbers of Aircraft Before Achieving the Final Production Milestone Poses a Cost Risk

As a result of delays in completing initial operational testing, DOD has postponed the F-35 full-rate production decision. Nevertheless, it continues to buy aircraft at near full production rates, which poses a risk of increased retrofit costs. As of February 2022, the program office had not finalized a new acquisition program baseline. Program officials stated this new baseline will include a revised date to make a full-rate production

decision. The program office has delayed the formal full-rate production decision at least five times since the program began, as we have previously reported.⁶ At this point, the full-rate production decision will occur more than a decade later than what the program office originally planned.

Continuing to purchase aircraft at high rates before completing testing can increase retrofit costs as the program continues to identify and resolve deficiencies. Deficiencies represent specific instances where the weapon system either does not meet requirements or its safety, suitability, or effectiveness could be adversely affected.

In June 2018, we recommended that the F-35 program office resolve all critical deficiencies before making a full-rate production decision.⁷ As of December 2021, the program office expected to resolve all four of its open critical deficiencies with the aircraft before the full-rate production decision.⁸ These four deficiencies are critical because they restrict the readiness of the aircraft but do not jeopardize safety. The program office also has identified 822 other less-critical open deficiencies. However, it does not plan to close all of these less-critical deficiencies prior to the full-rate production decision and will not address some.

Fixing deficiencies can require that the contractor redesign and replace equipment on aircraft already delivered, referred to as retrofitting. The more aircraft produced and delivered prior to resolving deficiencies, the greater the likelihood that DOD will have to retrofit aircraft, at the expense of the government.

If the full-rate production decision occurs in 2023, we estimate that the program will have delivered 1,115 aircraft before finishing initial

⁶[GAO-22-105128](#); 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); *F-35 Joint Strike Fighter: Actions Needed to Address Manufacturing and Modernization Risks*, [GAO-20-339](#) (Washington, D.C.: May 12, 2020); [GAO-19-341](#), and *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).

⁷[GAO-18-321](#).

⁸Critical deficiencies could jeopardize safety, security, or another requirement. Less-critical deficiencies could impede or constrain successful mission accomplishment. According to program officials, initial fixes for all four critical deficiencies have been implemented and are awaiting verification.

operational testing.⁹ This estimate represents about one third of the 3,360 aircraft currently forecasted to be purchased by the U.S., international partners, and foreign military sales. The program is also purchasing aircraft at relatively high rates—up to 152 per year. This level of production exceeds the level planned for some years after the draft full-rate production decision. Our past work indicates that purchasing large numbers of aircraft before completing testing, resolving deficiencies, and reaching the full-rate production milestone and its associated requirements, increases the risk of additional retrofit costs.¹⁰

Reliability and Maintainability Remain a Concern

Reliability and maintainability metrics, and the associated performance goals, are aimed at ensuring that an aircraft will be available for operations as opposed to out-of-service for maintenance. For the F-35, each variant is assessed against eight reliability and maintainability metrics, 24 in total. For example, one goal, referred to as Mean Time to Repair, measures the amount of time it takes a maintainer to repair a failed component or device.

After some previous improvements, some F-35 reliability and maintainability performance goals declined last year. In March 2021, we found that, as of June 2020, the program was meeting or close to meeting 17 of its 24 reliability and maintainability goals. However, as of December 2021, the program was meeting or close to meeting just 11 of its 24 goals.¹¹

Although the program is still not meeting 13 of its 24 reliability and maintainability goals, measurable improvements in these goals can take

⁹Of the 3,360 total aircraft purchased, DOD is planning to purchase 2,470 for the U.S., including 14 developmental testing aircraft.

¹⁰GAO, *KC-46 Tanker Modernization: Aircraft Delivery Has Begun, but Deficiencies Could Affect Operations and Will Take Time to Correct*, [GAO-19-480](#) (Washington, D.C.: June 12, 2019).

¹¹These metrics represent a 3-month average and reflect a snapshot in time. Measurable improvements can take time to manifest.

time to manifest.¹² For example, fielded aircraft must be modified and flown for many hours before the program can measure improvements. For more information each F-35 variants' performance against these metrics' targets, as of December 2021, the most recent available metrics, see appendix II.

In recent years, we made a number of recommendations to improve the F-35's reliability and maintainability, which the program has taken some actions to address. Specifically, in 2018, 2019, and 2020, we made a total of six reliability and maintainability-related recommendations, including that the program office takes steps to ensure those goals are met by aircraft maturity or revise those goals to be more achievable.¹³ DOD concurred with our recommendations and identified actions aimed at addressing them. To improve reliability and maintainability, the program office has prioritized funding and implementation of initiatives to improve these metrics. These efforts have been consistent with our previous recommendations.¹⁴ Overall, DOD has implemented four out of six; the remaining two a not yet implemented.

Program Modified Delivery Schedule to Mitigate Effects of Long-Standing Supply Chain and COVID-19 Challenges

In April 2022, we reported that the program office modified the contracted delivery date of near-term aircraft to help the contractor and the production line recover from ongoing supply chain challenges exacerbated by the COVID-19 pandemic. In particular, prior to the pandemic, we reported that late aircraft deliveries were largely a result of suppliers delivering parts to the production line later than needed.¹⁵ As we reported in March 2021, COVID-19 exacerbated these long-standing supply-chain issues and caused labor disruptions, leading to late deliveries of aircraft. The program faced significant production delays in 2020 and 2021 due to COVID-19 and the resulting supply chain issues. As a result, in September 2021, the program office and contractors

¹²Program officials stated that, while none of the variants are at or above the current targets established in the Joint Strike Fighter Operational Requirements Document—which outlines the requirements the Department of Defense and the military services agreed the F-35 should meet, they do meet more realistic targets approved by the F-35 Joint Executive Steering Board.

¹³[GAO-19-341](#).

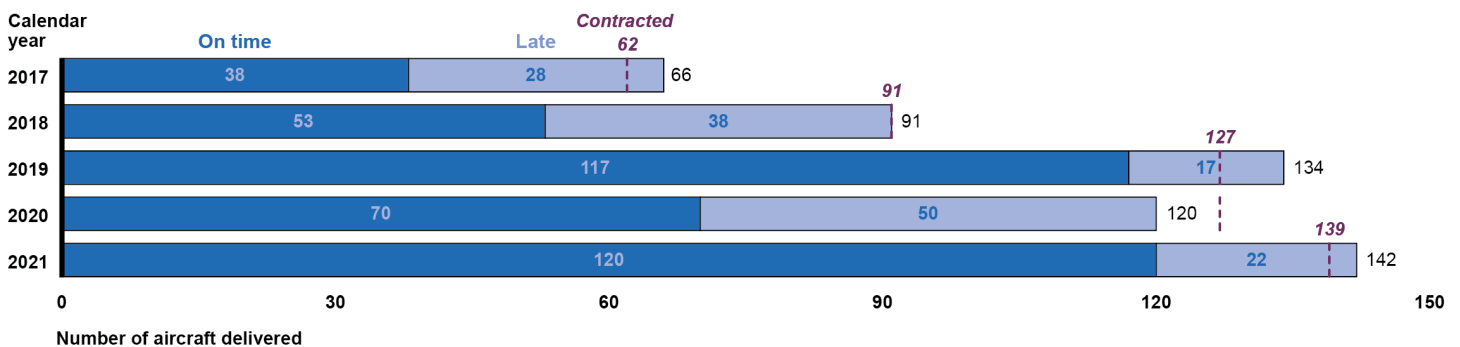
¹⁴[GAO-19-341](#) and [GAO-20-339](#).

¹⁵[GAO-18-321](#) and [GAO-19-341](#).

modified the delivery schedule to reduce the number of aircraft on contract for delivery in years 2020 through 2023. Program officials explained that they took these steps to reflect the unavoidable challenges of operating during the COVID-19 pandemic and to not unfairly penalize the contractor.

As part of the agreement to modify the number of aircraft contracted for delivery from 2020 to 2023, the program office also made adjustments to its scorekeeping for past deliveries. In particular, the program retroactively modified the contracted delivery dates of some aircraft delivered during this time frame, thereby revising what aircraft were considered late deliveries. As a result, after the modifications, some aircraft that had been previously considered late were now determined to be on time. For example, before the contract modification, 85 out of 120 would have been considered late. After modifying the delivery schedule, however, 50 out of 120 aircraft delivered in 2020 were considered late, as shown in figure 2.

Figure 2: F-35 Aircraft Deliveries, On Time and Late, 2017 through 2021



Source: GAO analysis of Department of Defense data. | GAO-22-105943

Accessible Data Table for Figure 2

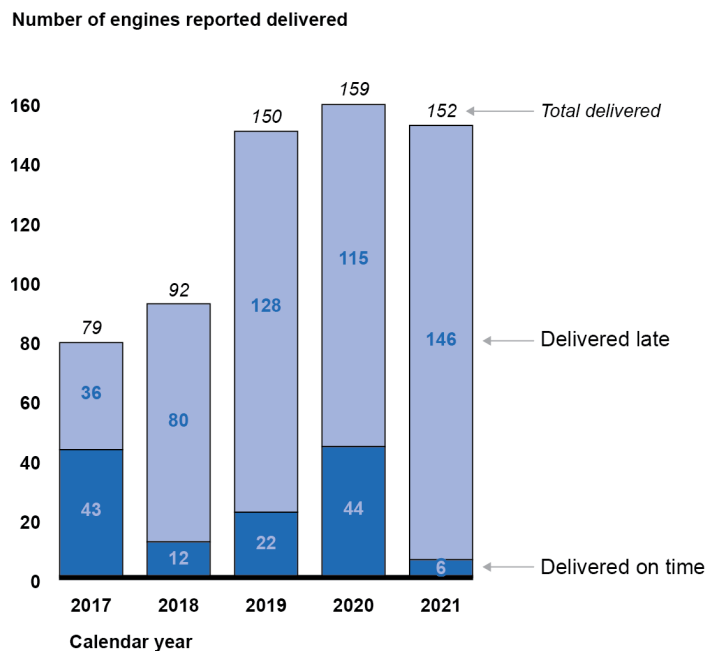
Calendar year	On time	Late	Total	Number contracted
2017	38	28	66	62
2018	53	38	91	91
2019	117	17	134	127
2020	70	50	120	127
2021	120	22	142	139

Note: The figure reflects deliveries by calendar year. Delivery totals for 2020 and 2021 reflect the modified contract dates. Aircraft contracted for delivery in a particular year may have been delivered in a different year. For example, Department of Defense officials told us that seven aircraft contracted for delivery in 2020 were delivered early in 2019. Contracted numbers reflect the total number of aircraft on contract for delivery that calendar year.

Nearly All Engines Were Late in 2021

In 2021, the engine contractor—Pratt & Whitney—continued to deliver more engines late than those it delivered on time. Program officials stated the later deliveries were primarily due to quality issues that required resolution before engines could be accepted by the government. These officials stated that quality issues resulted in the contractor delivering nearly all of the engines late in 2021. Specifically, program officials reported that some of the raw material used in production was manufactured by an incorrect method. Figure 3 illustrates recent year engine deliveries, late versus on time.

Figure 3: On-Time Engine Delivery for the F-35 Aircraft Declined in 2021



Source: GAO analysis of Pratt & Whitney data. | GAO-22-105943

Accessible Data Table for Figure 3

Number of engines reported delivered

Calendar year	Delivered on time	Delivered late	Total delivered
2017	43	36	79
2018	12	80	92
2019	22	128	150
2020	44	115	159
2021	6	146	152

In September 2021, the engine contractor reported submitting a corrective action plan to address issues with late deliveries and quality control and took steps to enhance delivery performance. The results of these efforts have yet to be determined.

F-35 Modernization Cost and Schedule Continue to Grow, and Changes Aimed at Improving Future Outcomes Are Underway

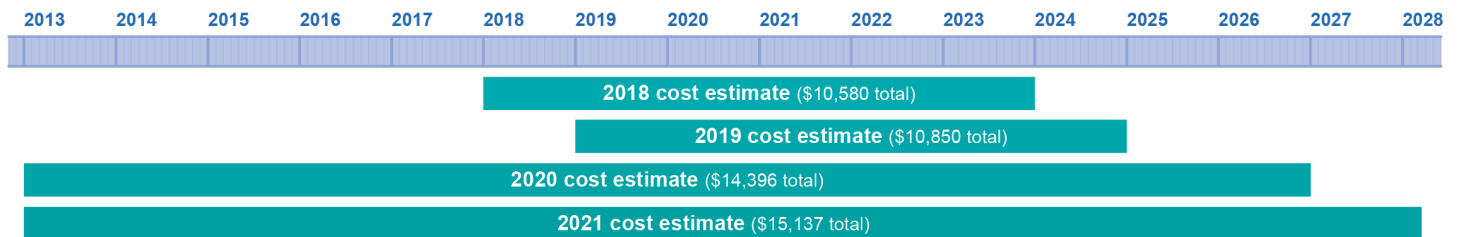
In April 2022, we reported that the F-35 program, now 4 years into its Block 4 modernization efforts, continues to experience cost increases and schedule delays, which continues to echo long-standing challenges of the baseline program. Costs continued to rise during 2021 due to crucial hardware development, among other things. The schedule also grew due to software quality issues, and the addition of new capabilities. In 2021, the program office added 3 years to its Block 4 schedule and now expects to extend Block 4 development and delivery into fiscal year 2029, in part, due to the addition of new capabilities. In 2021, the program office implemented changes to Block 4 development efforts to increase software quality and on-time deliveries, but it is too soon to evaluate the effects of these changes.

Modernization Will Cost More and Take Longer due to Key Hardware Upgrades, Persistent Software Quality Issues, and the Addition of New Capabilities

In 2021, the F-35 Block 4 development cost estimate increased to \$15.14 billion, which is \$741 million more than its 2020 estimate of \$14.4 billion. The primary drivers for the increase in the 2021 cost estimate include the increased costs of the Technology Refresh 3 (TR-3), which is the suite of hardware and some software technologies that will provide updated processing capability, display units, and increased memory to the aircraft.

Lab upgrades to modernize aging test infrastructure also contributed to increased costs. This most recent estimate is also \$4.6 billion more than the 2018 baseline, in part, because DOD expanded the scope of its estimate to reflect all related costs. DOD's estimate now includes costs that the program incurred before 2018, and those that the program now recognizes will continue after 2024, as shown in figure 4.¹⁶

Figure 4: Change in Block 4 Cost Estimates from 2018 through 2021 (2012 Then Year dollars in millions)



Source: GAO analysis of Department of Defense data. | GAO-22-105943

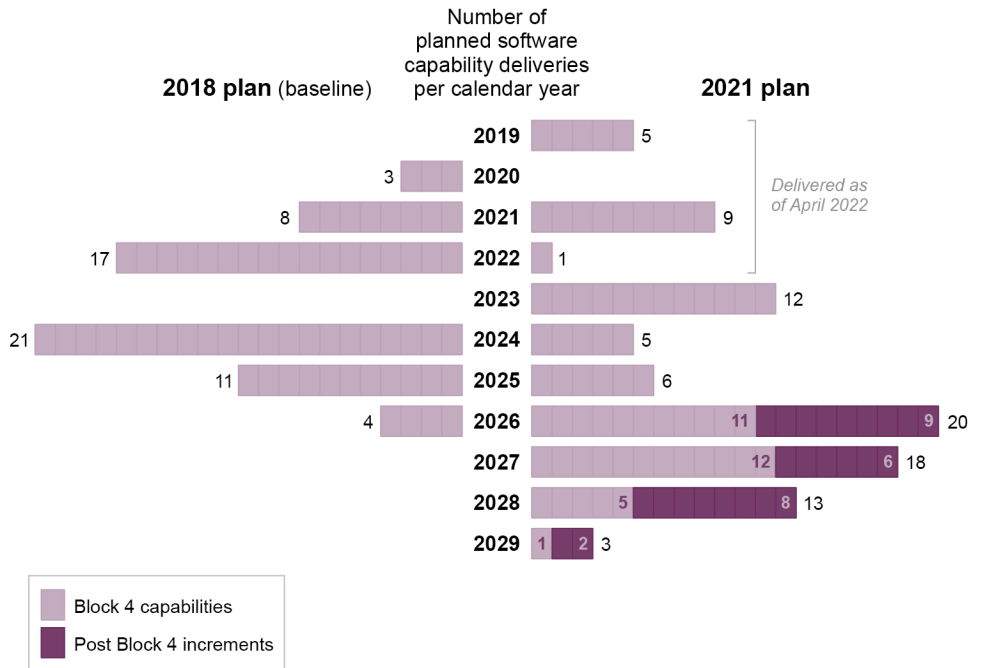
Note: The 2018 and 2019 estimates reflect a 6-year time frame as the Department of Defense focused its estimates on the future year's defense program. The future year's defense program is the department's projected spending for the current budget year and at least the next 4 years. The 2020 and 2021 estimate includes costs for the entirety of the program, including all prior years' actual costs and the additional years estimated to completion from the original 2018 estimate. Additionally, the 2021 cost estimate includes Block 4 development through 2028. However, the program office now plans to deliver the final Block 4 capabilities in 2029.

In addition to the cost increase, the program office continues to face delays in delivering Block 4 capabilities and added new, post-Block 4 efforts. As of 2021, the program office now plans to complete Block 4 capability deliveries 3 years later than the original schedule, due to software quality issues, funding challenges, and the addition of new capabilities, among other things.¹⁷ In addition, the program office has begun planning for the development and delivery of additional, post-Block 4 capabilities beyond the original capabilities planned for Block 4. Figure 5 shows the overall delay of planned capabilities in the 2018 baseline schedule compared to the 2021 schedule as well as the added post Block 4 modernization capabilities.

¹⁶In May 2020, we recommended that the Under Secretary of Defense for Acquisition and Sustainment direct the F-35 program office to establish a Block 4 cost estimate baseline that includes all Block 4 costs, including incurred costs and future costs in its reports to Congress. See [GAO-20-339](#).

¹⁷[GAO-21-226](#).

Figure 5: Revised Delivery Plan for Block 4 and Post-Block 4 Capabilities



Source: GAO representation of program office data. | GAO-22-105943

**Accessible Data Table for 5 (Part 1 of 2)
2018 plan (baseline)**

Number of planned software capability deliveries

calendar year	Block 4 capabilities	Post Block 4 increments	Total
2019	0		9
2020	3		13
2021	8		13
2022	17		2
2023	0		14
2024	21		21
2025	11		5
2026	4		4

**Accessible Data Table for 5 (Part 2 of 2)
2021 plan**

Number of planned software capability deliveries

calendar year	Block 4 capabilities	Post Block 4 increments	Total
2019	5 ^a		5 ^a
2020	0		0
2021	9 ^a		9 ^a
2022	1 ^a		1 ^a
2023	12		12
2024	5		5
2025	6		6
2026	11	9	20
2027	12	6	18
2028	5	8	13
2029	1	2	3

Notes:

This figure represents the F-35 program office's Block 4 and post-Block 4, software-enabled capability delivery plans from 2018 and 2021, respectively. We have previously reported that Block 4 is composed of 66 capabilities. However, some of those capabilities such as those related to the use of new weapons that required changes to hardware, like modifications to the aircraft's weapons bay, and the hardware elements are not represented in this graphic. Furthermore, since the program issued the 2018 plan, program officials explained that program has removed some capabilities, added new capabilities, and split capabilities up into multiple increments, in part, due to Turkey's removal from the program and new or changing priorities. Therefore, the total number of capabilities and the program office's time frame for delivering those capabilities has changed.

In prior years, based on information provided to us at that time, we have reported that the F-35 program office estimated that Block 4 development and delivery would be completed as early as 2024. This year, the program office provided us with a document from October 2018, which identified

that Block 4 capabilities would be delivered as late as 2026. We have updated this statement to reflect this new information.

We found three contributing factors for the recent Block 4 capability schedule delays. First, persistent software quality problems have resulted in additional work and continue to delay the testing and delivery of Block 4 capabilities. Second, an 8-month pause in Block 4 development occurred when the program office ran out of funds due to the TR-3 cost overrun noted above. Third, according to program officials, the overall delay in Block 4 development was also due to the addition of 25 capabilities added as part of a reprioritization of Block 4 capabilities.

In addition to these delays, the program office is monitoring additional schedule risks. The contractor plans to deliver the TR-3 upgrade to the production line by summer 2023. Program officials consider TR-3 a critical enabler to future Block 4 capabilities that they expect the contractor to deliver starting 2023. However, officials noted there are still risks associated with completing both the hardware and software needed to meet this updated schedule.

To address these risks, the program office is undertaking multiple mitigation efforts. For example, if TR-3 software is delayed beyond the time needed for production, program officials stated they would install the TR-3 hardware, which is likely to be completed at that time, and install the delayed software later. If the TR-3 hardware is delayed, the program office plans to install TR-2 hardware and software kits to fill the production gap and retrofit the aircraft with TR-3 kits when they are available. Officials acknowledge that any further delays in TR-3 development could result in a corresponding delay to Block 4 capabilities that require TR-3 to function.

Changes to Block 4 Implementation Are Too Early to Assess

Faced with the ongoing software quality problems discussed above, in 2020, the F-35 program office and Lockheed Martin commissioned an independent review team of experts to recommend improvements in the Block 4 development process. The review covered a wide range of topics, including the use of Agile software principles as well as the infrastructure,

tools, and processes used by the Block 4 development teams.¹⁸ The review team, which provided its results to the program office in November 2020, made several recommendations to improve software quality and reduce delays. In some cases, the findings of this review and its recommendations were similar to recommendations we made in March 2021 to improve Block 4 cost and schedule performance.¹⁹ Specifically, in March 2021, we recommended that the Undersecretary of Defense for Acquisition and Sustainment should direct the F-35 program office to

- Update its modernization schedule to reflect achievable timeframes,
- Identify and implement tools to enable automated data collection on software development performance, and
- Set software quality performance targets.²⁰

DOD concurred with each of these recommendations and while some actions are underway, as outlined below, all remain open.

In 2021, program officials and Lockheed Martin representatives began to implement a number of actions, in part, to address our 2021 recommendations as well as the findings from its independent review team. These actions include:

- increasing laboratory-based software testing,
- enhancing monitoring of development progress,
- adjusting the software development schedule, and
- adapting the upcoming Block 4 contract to align with some Agile best practices.

While these steps are aimed at improving future Block 4 outcomes, they have been implemented too recently to assess or are still ongoing. For example the next contract has yet to be negotiated. We will continue to

¹⁸Agile software development supports the practice of shorter software delivery. Specifically, Agile calls for the delivery of software requirements in small, manageable, predetermined increments based on an “inspect and adapt” approach where the requirements change frequently and software is released in increments. GAO, *Agile Assessment Guide: Best Practices for Agile Adoption and Implementation*, [GAO-20-590G](#) (Washington, D.C.: Sept. 28, 2020).

¹⁹[GAO-21-226](#).

²⁰[GAO-21-226](#).

monitor the program's progress to address challenges with Block 4 modernization.

In conclusion, development of the F-35 has taken over 10 years longer and the program is expected to cost \$165 billion more than originally planned, so far. Although not expected to be approved for full-rate production for a year or more, the program is producing aircraft at rates similar to those planned for full-rate production. Continuing to purchase aircraft at high rates before completing the long-delayed simulator testing could further increase retrofit costs as the program continues to identify and resolve deficiencies.

At the same time that the program is resolving risks with the aircraft and the baseline systems, DOD continues to encounter similar cost and schedule increases with Block 4 modernization. The program is more than 4 years into modernizing the aircraft and continues to encounter cost growth and schedule delays. Going forward, the program must continue to monitor TR-3 schedule risk. This is critical for ensuring the aircraft can receive all Block 4 capabilities as scheduled and function at its fullest potential in the current threat environment. Collectively these risks reinforce the importance of continued congressional oversight of the program.

However, the program office is taking steps to implement software development improvements and include mechanisms to address best practices for Agile contracting in its next Block 4 contract. Effective implementation of these steps and GAO's prior Block 4 recommendations can lead to improved modernization outcomes.

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 at this time. 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.

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

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

Year, GAO report	Estimated F-35 development costs, development length, and aircraft unit cost ^a	Key program event	Primary GAO conclusions and recommendations	DOD response
Joint Strike Fighter Acquisition: Mature Critical Technologies Needed to Reduce Risks				
2001 GAO-02-39	\$34.4 billion 10 years \$69 million	Start of system development and demonstration approved.	Critical technologies needed for key aircraft performance elements were not mature. We recommended that the program delay start of system development until critical technologies were 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 would manage risks in development. We closed both of these recommendations as not implemented.
Joint Strike Fighter: DOD Plans to Enter Production before Testing Demonstrates Acceptable Performance				
2006 GAO-06-356	\$45.7 billion 12 years \$86 million	Program put in motion plan to enter production in 2007 shortly after first flight of the non-production representative aircraft.	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 showed that the F-35 performed as expected.	DOD partially concurred but did not delay start of production because it reported it believed the risk level was appropriate. We closed two recommendations as implemented and one recommendation as not implemented.
Joint Strike Fighter: Additional Costs and Delays Risk Not Meeting Warfighter Requirements on Time				

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

Year, GAO report	Estimated F-35 development costs, development length, and aircraft unit cost^a	Key program event	Primary GAO conclusions and recommendations	DOD response
2010 GAO-10-382	\$49.3 billion 15 years \$112 million	The program was restructured to reflect findings from a recent independent cost team and independent manufacturing review team. As a result, development funds increased, test aircraft were added, the schedule was extended, and the early production rate decreased.	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. We closed these recommendations as implemented.

F-35 Joint Strike Fighter: Problems Completing Software Testing May Hinder Delivery of Expected Warfighting Capabilities

2014 GAO-14-322	\$55.2 billion 18 years \$135 million	The military services established new initial operational capabilities dates. The Marine Corps and Air Force planned to field initial operational capabilities in 2015 and 2016, respectively, and the Navy planned to field its initial capability in 2018.	Delays in developmental flight testing of the F-35's critical software hindered delivery of the warfighting capabilities to the military services. We recommended that DOD conduct an assessment of the specific capabilities that could be delivered and those that would 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 GAO's recommendation. We closed this recommendation as implemented.
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F-35 Joint Strike Fighter: Continued Oversight Needed as Program Plans to Begin Development of New Capabilities

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

Year, GAO report	Estimated F-35 development costs, development length, and aircraft unit cost^a	Key program event	Primary GAO conclusions and recommendations	DOD response
2016 GAO-16-390	\$55.1 billion 18 years \$130.6 million	DOD planned to begin what it referred to as a block buy contracting approach that was anticipated to provide cost savings. In addition, DOD planned to manage the follow-on modernization program under the current F-35 program baseline and not as its own separate major defense acquisition program.	The terms and conditions of the planned block buy and managing follow-on modernization under the current baseline could have presented 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. It stated that the existing oversight mechanisms, including regularly scheduled high-level acquisition reviews, would be used to manage the effort. We closed the recommendation as not implemented.

F-35 Joint Strike Fighter: DOD Needs to Complete Developmental Testing Before Making Significant New Investments

**Appendix I: Selected Prior GAO Reports on the
F-35 Acquisition Program and Department of
Defense Responses**

Year, GAO report	Estimated F-35 development costs, development length, and aircraft unit cost^a	Key program event	Primary GAO conclusions and recommendations	DOD response
2017 GAO-17-351	\$55.1 billion 18 years \$130.6 million	The DOD F-35 program office was considering contracts for economic order quantity of 2 years' worth of aircraft parts followed by a separate annual contract for procurement of lot-12 aircraft with annual options for lot-13 and lot-14 aircraft. However, as of January 2017, contractors stated they were still negotiating the terms of this contract; therefore, the specific costs and benefits remained uncertain.	Program officials projected that the program would only need \$576.2 million in fiscal year 2018 to complete original program 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. We 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. It stated 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. We closed two recommendations as implemented and one as not implemented.

**Appendix I: Selected Prior GAO Reports on the
F-35 Acquisition Program and Department of
Defense Responses**

Year, GAO report	Estimated F-35 development costs, development length, and aircraft unit cost^a	Key program event	Primary GAO conclusions and recommendations	DOD response
2018 GAO-18-321	\$55.5 billion 18 years \$140.6 million	The program office determined that it could not resolve all open deficiencies found in developmental testing within the development program, and it would need to be resolved through post-development contract actions. DOD provided a report to Congress outlining preliminary plans to modernize the F-35. It stated it planned to develop a full acquisition program baseline for the modernization effort in 2018 and planned to provide a report to Congress by March 2019.	The program office planned 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 the congressional defense committees a report on its complete acquisition program baseline for the Block 4 effort.	DOD concurred with both recommendations and identified actions that it would take in response. We closed both of our recommendations as implemented. The John S. McCain 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.

**Appendix I: Selected Prior GAO Reports on the
F-35 Acquisition Program and Department of
Defense Responses**

Year, GAO report	Estimated F-35 development costs, development length, and aircraft unit cost^a	Key program event	Primary GAO conclusions and recommendations	DOD response
2019 GAO-19-341	\$55.5 billion 18 years \$140.6 million	For as long as the program has tracked reliability and maintainability performance, it has realized only minimal, annual improvement. Half of these metrics are failing and unlikely to meet targets outlined in the Operational Requirements Document by full aircraft maturity. As of December 2018, not all reliability and maintainability metrics within the Operational Requirements Document have been met, nor reevaluated to determine more realistic reliability and maintainability performance metrics.	<p>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.</p> <p>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.</p>	<p>DOD concurred with our four recommendations on reliability and maintainability and identified actions it would take in response. DOD has taken some action, and we have closed three of the four recommendations as implemented.</p> <p>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. Though these items were completed after DOD conducted additional development work, as of July 2020, the F-35 program office has completed an independent cost estimate, an approved test and evaluation master plan, and systems engineering plan. We closed the recommendation as implemented.</p>

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

Year, GAO report	Estimated F-35 development costs, development length, and aircraft unit cost^a	Key program event	Primary GAO conclusions and recommendations	DOD response
2020 GAO-20-316	\$57.3 billion 19 years \$144.7 million	The Autonomic Logistics Information System (ALIS) is integral to supporting the F-35 fighter jet's operations and maintenance. We noted that we previously reported on key risks associated with the system, such as challenges deploying the F-35 with ALIS, inaccurate data that reside in ALIS, and ineffective training for personnel who need to use ALIS. We reported that DOD and the prime contractor had a variety of initiatives underway for redesigning ALIS.	We suggested that Congress consider requiring DOD to develop a performance measurement process for ALIS. We also recommended that DOD track how ALIS is affecting readiness of the F-35 fleet and develop a strategy for the ALIS redesign.	DOD concurred with both of our recommendations and identified actions that it was taking or planned in response. We agreed that DOD was taking positive steps in addressing issues with ALIS, including the decision to replace ALIS with a future system that it has named the Operational Data Integrated Network (ODIN). According to DOD, the department was developing a strategy that would guide ODIN's development. We closed this recommendation as implemented. Our other recommendation related to tracking the effect of ALIS on readiness remains open.

F-35 Joint Strike Fighter: Actions Needed to Address Manufacturing and Modernization Risks

2020 GAO-20-339	\$57.3 billion 19 years \$144.7 million	In 2019, the F-35 program conducted much of its planned operational testing but extended the schedule by 9 months, which delayed the program's full-rate production decision to between September 2020 and March 2021. In addition, the program was not meeting manufacturing leading practices identified by GAO and its Block 4 development cost estimate did not adhere to GAO leading practices.	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 were 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, would meet the intent of these recommendations. DOD concurred with our three other recommendations. We closed as implemented our recommendation related to establishing a Block 4 cost estimate baseline that includes all costs. Our other four recommendations remain open.
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F-35 Joint Strike Fighter: DOD Needs to Update Modernization Schedule and Improve Data on Software Development

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

Year, GAO report	Estimated F-35 development costs, development length, and aircraft unit cost^a	Key program event	Primary GAO conclusions and recommendations	DOD response
2021 GAO-21-226	\$57.5 billion 20 years \$131.3 million	The program office delayed full-rate production to an unknown date due to ongoing delays with simulator testing. Block 4 cost and schedule increased, and the program faced challenges in tracking Block 4 software development metrics.	We made three recommendations to the Undersecretary of Defense for Acquisition and Sustainment to direct the F-35 program office to update its Block 4 schedule to reflect historical performance and develop more achievable time frames; 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 of our recommendations and identified actions it would take in response. These recommendations remain open.

Source: GAO | GAO-22-105943

^aThe aircraft unit cost is the program's average procurement unit cost estimate, which is calculated by dividing the procurement amount by the procurement aircraft quantities. This is different than the negotiated price for F-35 aircraft, also reported above.

Appendix II: F-35 Reliability and Maintainability Metrics

Table 2: The F-35 Reliability and Maintainability Metrics' Performance as of December 2021

	Contractually required	F-35A	F-35B	F-35C
Mission reliability—measures the probability of successfully completing a mission of average duration	Metric is contractually required	Metric is at or above minimum targets	Metric is at or above current targets	Metric is at or above current targets
Mean flight hours between failure (design controlled)—measures time between failures that are directly attributable to the design of the aircraft and are considered fixable with design changes	Metric is contractually required	Metric is at or above current targets	Metric is at or above current targets	Metric is at or above current targets
Mean time to repair—measures the amount of time it takes a maintainer to repair a failed component or device	Metric is contractually required	Metric is at or above minimum targets	Metric is at or above minimum targets	Metric is at or above current targets
Maintenance man hours per flight hour—measures the average amount of time spent on scheduled and unscheduled maintenance per flight hour	Metric is contractually required	Metric is at or above current targets	Metric is at or above current targets	Metric is at or above current targets
Mean flight hours between maintenance events—also referred to as the logistics reliability metric, measures time between maintenance, unscheduled inspections, and servicing actions	Metric is not contractually required	Metric is at or above minimum targets	Metric is at or above current targets	Metric is below minimum targets
Mean flight hours between removals—measures the time between part removals from the aircraft for replacement from the supply chain	Metric is not contractually required	Metric is at or above minimum targets	Metric is below minimum targets	Metric is at or above minimum targets

Appendix II: F-35 Reliability and Maintainability Metrics

	Contractually required	F-35A	F-35B	F-35C
Mean flight hours between critical failure—measures the time between failures that result in the loss of a capability to perform a mission-critical capability	Metric is not contractually required	Metric is below minimum targets	Metric is below minimum targets	Metric is at or above current targets
Mean corrective maintenance time for critical failure—measures the amount of time it takes to correct critical failure events	Metric is not contractually required	Metric is below minimum targets	Metric is below minimum targets	Metric is below minimum targets

Source: GAO analysis of contractor data. | GAO-22-105943

Note: Each metric is measured using a 3-month average and reported on a monthly basis; this table summarizes the Lockheed Martin Reliability and Maintainability Report December 21, data measured from July 2021 through September 2021.

^aMaintenance man hours per flight hour is tracked as unscheduled, scheduled, and total. We report the total metric in this table because it is an F-35 Operational Requirements Document requirement.

GAO Contact and Staff Acknowledgments

If you or your staff have any questions about this testimony, please contact Jon Ludwigson, Director, Contracting and National Security Acquisitions, at (202) 512-4841 or 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 Stevens (Analyst in Charge), James Bennett, Laura Greifner, Kya Palomaki, and Lauren Wright. Other staff who made key contributions to the reports cited in the testimony are identified in the source products.

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