

March 2013

# F-35 JOINT STRIKE FIGHTER

## Current Outlook Is Improved, but Long- Term Affordability Is a Major Concern



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## Why GAO Did This Study

The F-35 Lightning II, the Joint Strike Fighter, is DOD's most costly and ambitious aircraft acquisition. The program is developing and fielding three aircraft variants for the Air Force, Navy, Marine Corps, and eight international partners. The F-35 is critical to long-term recapitalization plans as it is intended to replace hundreds of existing aircraft. This will require a long-term sustained funding commitment. Total U.S. investment is nearing \$400 billion to develop and procure 2,457 aircraft through 2037. Fifty-two aircraft have been delivered through 2012. The F-35 program has been extensively restructured over the last 3 years to address prior cost, schedule, and performance problems. GAO's prior reviews of the F-35 made numerous recommendations to improve outcomes, such as increasing test resources and reducing annual procurement quantities.

This report, prepared in response to the National Defense Authorization Act for 2010, addresses (1) F-35 program performance during 2012, including testing, technical risks, and software; (2) manufacturing performance indicators, production results, and design changes; and (3) acquisition and sustainment costs going forward. GAO's work included analyses of a wide range of program documents and interviews with defense and contractor officials.

## What GAO Recommends

GAO is not making recommendations in this report. DOD's restructuring of the F-35 program and other actions are responsive to many prior recommendations. DOD agreed with GAO's report findings and conclusions.

View [GAO-13-309](#). For more information, contact Michael J. Sullivan at (202) 512-4841 or [sullivanm@gao.gov](mailto:sullivanm@gao.gov).

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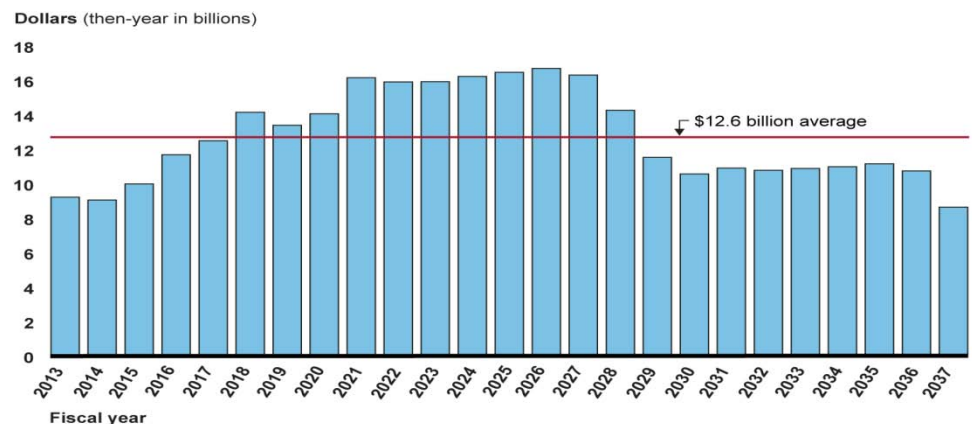
### What GAO Found

The F-35 program achieved 7 of 10 key management objectives for 2012 and made substantial progress on one other. Two objectives on aircraft deliveries and a corrective management plan were not met. Also in 2012, the program conducted more developmental flight tests than planned and made considerable progress in addressing critical technical risks, such as the helmet-mounted display. With about one-third of development flight testing completed, much testing remains to demonstrate and verify F-35 performance. Software management practices are improved, but with significant challenges ahead as software integration and testing continue to lag behind plans.

Manufacturing and supply processes are also improving—indicators such as factory throughput, labor efficiency, and quality measures are all positive. While initial F-35 production overran target costs and delivered aircraft late, the latest data shows labor hours decreasing and deliveries accelerating. The program is working through the continuing effects from its concurrent acquisition strategy that overlapped testing and manufacturing activities. For example, the program is continuing to incur substantial costs for rework to fix deficiencies discovered in testing, but the amount of rework needed on each aircraft is dropping.

Going forward, ensuring affordability—the ability to acquire aircraft in quantity and to sustain them over the life cycle—is of paramount concern. With more austere budgets looming, F-35 acquisition funding requirements average \$12.6 billion annually through 2037 (see below). The new F-35 acquisition baseline incorporates the Department of Defense's (DOD) positive restructuring actions taken since 2010, including more time and funding for development and deferred procurement of more than 400 aircraft to future years. These actions place the F-35 program on firmer footing, although aircraft will cost more and deliveries to warfighters will take longer. The program continues to incur financial risk from its plan to procure 289 aircraft for \$57.8 billion before completing development flight testing. Meanwhile, the services are spending about \$8 billion to extend the life of existing aircraft and to buy new ones to mitigate shortfalls due to F-35 delays.

**F-35 Joint Strike Fighter Acquisition Funding Requirements**



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# Contents

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Letter		1
	Background	3
	Program Made Progress in 2012, but Majority of Testing Still Ahead After a Slow Start, Aircraft Manufacturing and Deliveries Are Beginning to Catch Up to Plans	5
	Costs and Funding for Acquisition and Sustainment Remain Very Challenging Moving Forward	15
	Concluding Observations	23
	Agency Comments and Our Evaluation	27
Appendix I	Prior GAO Reports and DOD Responses	27
Appendix II	Scope and Methodology	33
Appendix III	Comments from the Department of Defense	35
Appendix IV	GAO Contact and Staff Acknowledgment	36
Related GAO Products		37
Tables		
	Table 1: Changes in Reported F-35 Program Quantity, Cost, and Deliveries, 2001-2012	5
	Table 2: F-35 Program Results for 2012 Objectives	7
	Table 3: Procurement Contract Costs as of September 2012	18
	Table 4: F-35 Procurement Investments and Flight Test Progress	23
Figures		
	Figure 1: F-35 Flight Test Points Progress in 2012	9
	Figure 2: Percent of Sensor Fusion Development in Each Software Block	14

---

Figure 3: F-35 Deliveries Compared to Contract Dates	19
Figure 4: F-35 Engineering Design Changes	21
Figure 5: Mean Flying Hours between Failures	22
Figure 6: F-35 Program Budgeted Development and Procurement Funding Requirements, Fiscal Years 2013-2037	24

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### Abbreviations

ALIS	Autonomic Logistics Information System
CAPE	Cost Assessment and Program Evaluation
CDR	critical design review
CTOL	conventional takeoff and landing
CV	carrier variant
DCMA	Defense Contract Management Agency
DOD	Department of Defense
DOT&E	Director, Operational Test and Evaluation
DT	development testing
DT&E	Development Test and Evaluation
EVMS	Earned Value Management System
IOC	initial operational capability
JSF	Joint Strike Fighter
LRIP	low rate initial production
OSD	Office of the Secretary of Defense
SDD	system development and demonstration
STOVL	short takeoff and vertical landing

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United States Government Accountability Office  
Washington, DC 20548

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March 11, 2013

### Congressional Committees

At a cost approaching \$400 billion, the F-35 Lightning II—also known as the Joint Strike Fighter—is the Department of Defense’s (DOD) most costly and ambitious acquisition program. The program is developing and fielding three aircraft variants for the Air Force, Navy, and Marine Corps and eight international partners. The F-35 is the linchpin of U.S. and partner plans to replace existing fighters and support future combat operations. In a time of more austere federal budgets, the F-35 program as planned will require long-term sustained funding in the billions of dollars while, at the same time, competing against other expensive defense items. Over the last 3 years, DOD has extensively restructured the program to address relatively poor cost, schedule, and performance outcomes.

We have reported on F-35 issues for a number of years.<sup>1</sup> While a program as complex and technically challenging as the F-35 would be expected to have setbacks, we have reported that the magnitude and persistence of the program’s cost and schedule problems can be largely traced to (1) a highly concurrent acquisition strategy that significantly overlapped development, testing, and manufacturing activities; and (2) decisions at key junctures made without adequate product knowledge.<sup>2</sup> We have made numerous recommendations in our prior reports aimed at reducing risks and improving chances for successful outcomes. DOD has taken actions on these recommendations to varying degrees. Our June 2012 report concluded that the department’s recent, extensive restructuring actions were positive improvements that should lead to more achievable and predictable outcomes, albeit at higher costs and extended

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<sup>1</sup>See related GAO products at the end of this report.

<sup>2</sup>We have an extensive body of work looking at knowledge-based best practices in successful private and public acquisitions of new technology. Defense policy and the Weapon Systems Acquisition Reform Act of 2009 incorporate elements of the knowledge-based approach. For an overview of the best practices criteria and methodologies, and how current defense programs including the F-35 fared, see GAO, *Defense Acquisitions: Assessments of Selected Weapon Programs*, [GAO-12-400SP](#) (Washington, D.C.: Mar. 29, 2012).

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times to test and deliver capabilities to warfighters.<sup>3</sup> Given likely future budget constraints and pressures, we recommended that DOD analyze cost and program impacts from potentially reduced future funding levels. We also recommended that DOD assess the capability and challenges facing the F-35's global supply chain that will be critical to supporting efficient and quality production at higher annual rates expected in the future. Our June 2012 and prior reports, recommendations, and DOD actions are summarized in appendix I.

The National Defense Authorization Act for Fiscal Year 2010 requires GAO to review the F-35 acquisition program annually for 6 years. This is the 4th report under this mandate, and in it, we address (1) program performance during 2012, including testing results, software, and technical risks; (2) manufacturing and supply performance indicators, production results, and design changes; and (3) acquisition and sustainment costs going forward. To conduct this work, we reviewed program status reports and briefings, management objectives, test plans and results, and internal DOD analyses with a focus on accomplishments in calendar year 2012 compared to original plans for that year. We obtained manufacturing data and cumulative outputs from the start of production in 2007 through the end of 2012, discussed development and production issues and results to date, future expansion plans, and improvement efforts with DOD, F-35 program, and contractor officials. We toured the aircraft manufacturing plant, obtained production and supply performance indicators, identified cumulative and projected engineering changes, and discussed factory improvements and management controls with members of the contractor's work force and DOD plant representatives. We evaluated DOD's restructuring actions and impacts on the program, tracked cost and schedule changes from program start to the new baseline, and determined factors driving the changes. We obtained current projections of acquisition funding needs through 2037 and ongoing efforts to project life cycle sustainment funding requirements. Appendix II contains a more detailed description of our scope and methodology.

We conducted this performance audit from August 2012 to March 2013 in accordance with generally accepted government auditing standards.

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<sup>3</sup>GAO, *Joint Strike Fighter: DOD Actions Needed to Further Enhance Restructuring and Address Affordability Risks*, [GAO-12-437](#) (Washington, D.C.: June 14, 2012).

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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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## Background

The F-35 Joint Strike Fighter program is a joint, multinational acquisition intended to develop and field an affordable, highly common family of next generation strike fighter aircraft for the United States Air Force, Navy, Marine Corps, and eight international partners.<sup>4</sup> The F-35 is a single-seat, single-engine aircraft incorporating low-observable (stealth) technologies, defensive avionics, advanced sensor fusion, internal and external weapons, and advanced prognostic maintenance capability. There are three variants. The conventional takeoff and landing (CTOL) variant, designated the F-35A, will be a multi-role, stealthy strike aircraft replacement for the Air Force's F-16 Falcon and the A-10 Thunderbolt II aircraft, and will complement the F-22A Raptor. The short takeoff and vertical landing (STOVL) variant, the F-35B, will be a multi-role stealthy strike fighter to replace the Marine Corps' F/A-18C/D Hornet and AV-8B Harrier aircraft. The carrier-suitable variant (CV), the F-35C, will provide the Department of Navy a multi-role, stealthy strike aircraft to complement the F/A-18 E/F Super Hornet. Lockheed Martin is the aircraft contractor and Pratt & Whitney is the engine contractor.

DOD began the Joint Strike Fighter program in October 2001 with a highly concurrent, aggressive acquisition strategy with substantial overlap between development, testing, and production. The program was rebaselined in 2004 following weight and performance problems and rebaselined again in 2007 because of additional cost growth and schedule slips. Following an extensive department-wide review, the Secretary of Defense in February 2010 announced a major restructuring of the program due to poor cost and schedule outcomes and continuing problems. DOD added time and money for development, provided additional resources for testing, and reduced the number of aircraft to be procured in the near-term. In March 2010, the department declared that

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<sup>4</sup>The international partners are the United Kingdom, Italy, the Netherlands, Turkey, Canada, Australia, Denmark, and Norway. These nations contributed funds for system development and signed agreements to procure aircraft. In addition, Israel and Japan have signed on as foreign military sales customers.

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the program exceeded critical cost growth thresholds established by statute—a condition known as a Nunn-McCurdy breach—and subsequently certified to the Congress in June 2010 that the F-35 program should continue.<sup>5</sup> Due to the cost breach, the Under Secretary of Defense for Acquisition, Technology, and Logistics rescinded the program's approval to enter system development and DOD began efforts to establish a new acquisition program baseline. The department continued restructuring actions during 2011 and 2012 that added more cost, extended schedules, and further reduced aircraft procurement quantities in the near-term. The quantity of F-35 aircraft to be procured in total was not changed, but restructured plans have deferred to future years the procurement of 410 aircraft originally planned to be procured through 2017 based on the 2007 revised baseline. Through the end of calendar year 2012, the contractor has delivered a total of 52 aircraft—14 test and 38 production aircraft.

In March 2012, DOD established a new acquisition program baseline for the F-35 program that incorporated the numerous positive and more realistic restructuring actions taken since 2010. Officials also reauthorized continuation of system development, approved continuation of low rate initial procurement, divided the program for reporting purposes into aircraft and engine subprograms, and took other actions required due to the Nunn-McCurdy cost breach. The March 2012 baseline is the F-35's fourth, including the original estimate at the start of development in October 2001. Table 1 shows changes in cost, quantity, and major schedules associated with each baseline and also a June 2010 interim estimate at the time of Nunn-McCurdy breach. The causes of cost growth and schedule delays from 2001 to 2012 are documented in past GAO reports (see appendix I and Related Products).

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<sup>5</sup>Commonly referred to as Nunn-McCurdy, 10 U.S.C. § 2433 establishes the requirement for DOD to submit unit cost reports on major defense acquisition programs or designated major subprograms. Procurement and acquisition unit costs are tracked against the current and original baseline estimates for a program. Increases in unit costs over certain thresholds constitute breaches in unit cost growth and, when the critical cost growth threshold is breached, DOD is required under 10 U.S.C. §2433a to take certain steps to explain and justify continuation of the program.



**Table 1: Changes in Reported F-35 Program Quantity, Cost, and Deliveries, 2001-2012**

	October 2001 (system development start)	December 2003 (approved baseline)	March 2007 (approved baseline)	June 2010 (Nunn-McCurdy)	March 2012 (approved baseline)
<b>Expected quantities</b>					
Development quantities	14	14	15	14	14
Procurement quantities (U.S. only)	2,852	2,443	2,443	2,443	2,443
Total quantities	2,866	2,457	2,458	2,457	2,457
<b>Cost estimates (then-year dollars in billions)</b>					
Development	\$34.4	\$44.8	\$44.8	\$51.8	\$55.2
Procurement	196.6	199.8	231.7	325.1	335.7
Military construction	2.0	0.2	2.0	5.6	4.8
Total program acquisition	\$233.0	\$244.8	\$278.5	\$382.5	\$395.7
<b>Unit cost estimates (then-year dollars in millions)</b>					
Program acquisition	\$81	\$100	\$113	\$156	\$161
Average procurement	69	82	95	133	137
<b>Estimated delivery and production dates</b>					
First production aircraft delivery	2008	2009	2010	2010	2011
Initial operational capability	2010-2012	2012-2013	2012-2015	TBD	TBD
Full-rate production	2012	2013	2013	2016	2019

Source: GAO analysis of DOD data.

Note: TBD means to be determined.

## Program Made Progress in 2012, but Majority of Testing Still Ahead

The F-35 program made progress in 2012 on several fronts. The program met or substantially met most of its key management objectives established for the year. Also, development flight testing exceeded the planned number of flights by a good margin for 2012, but did not quite accomplish the planned number of test points.<sup>6</sup> The program made considerable progress in addressing significant technical risks needing resolution, such as the helmet mounted display. Furthermore, software management practices improved, but this area continued to require more time and effort than planned. While the F-35 program made progress in

<sup>6</sup>Flight test points are specific, quantifiable objectives in flight plans that are need to verify aircraft design and performance.

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2012, the bulk of development testing and evaluation is ahead, is planned to continue into 2016, and is expected to identify additional deficiencies impacting aircraft design and performance. To date, slightly more than 11 percent of development contract performance specifications have been verified as met and the development flight test program has cumulatively accomplished just over one-third of the test points and test flights planned. The operational test community raised concerns about the F-35 readiness for training, development test plans and results, and the schedule and resources for starting initial operational testing in 2017.

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**F-35 Program Met Most of Its 2012 Key Management Objectives**

The F-35 program office annually establishes major management objectives it wants to achieve in the upcoming year. The program achieved 7 of the 10 primary objectives (70 percent) it established for 2012 and made substantial progress on one other. Table 2 summarizes the 2012 objectives and accomplishments.

**Table 2: F-35 Program Results for 2012 Objectives**

Objective	Was objective met?	Accomplishments	
<b>Test</b>	Complete Block 1A and 1B Development Test and Evaluation (DT&E)	Yes	Block 1A DT&E was completed in January 2012 and Block 1B in March 2012.
	Complete Block 3 Critical Design Review (CDR) #1	No	Block 3 preliminary design review closed in November 2012. Block 3 CDR #1 was conducted in late January 2013.
	Begin Lab Testing of Dual Path Helmet Mounted Display Systems	Yes	Both helmets are undergoing extensive testing.
<b>Training</b>	Begin F-35A and F-35B Pilot Training at Eglin Integrated Training Center	Yes	F-35A first flight at Eglin in March and F-35B in May. Operational utility evaluations completed by November 2012. Maintenance training also under way. The Air Force declared 'Ready for Training' in December 2012.
<b>Contract</b>	Conduct Defense Acquisition Board to recertify the start of system development	Yes	Defense Acquisition Board met in February and recertified the F-35 program in a March 2012 acquisition decision memorandum.
	Complete Restructured Development Contract Negotiations	Yes	Contract negotiations were completed in December 2012.
<b>Cost/ Schedule</b>	Improve F-35 Production Cost Performance	Yes	Cost indices improved for lot 4 compared to previous lots. Labor hours also decreasing.
	Deliver 40 F-35 Aircraft during 2012	No	Due to manufacturing delays, labor strike, and other reasons, the contractor delivered 30 aircraft during 2012.
	Successful Completion of Defense Contracting Management Agency (DCMA) Earned Value Management System (EVMS) Audit	No	DCMA rejected the aircraft contractor's EVMS corrective action plan in November for lack of progress. Contractor resubmitted its plan in January 2013 and DCMA is currently assessing it.
	Mature F-35 Supplier Network	Yes	Performance measures such as parts shortages, out of station work, and scrap rates are improving.

Source: GAO analysis of DOD data.

Note: Blocks refer to increments of software capability. There are 3 major software blocks.

In addition to the 7 objectives met, the F-35 program substantially met one more—the block 3 critical design review was completed in late January 2013 following the preliminary design review in November 2012. The remaining two objectives that were not met: (1) the contractor delivered 30 production aircraft compared to the program goal of 40 and (2) its Earned Value Management System (EVMS) corrective action plan was not approved. EVMS compliance is a long-standing issue and concerns all Lockheed Martin aircraft produced for DOD, not just the F-35. In 2007, the Defense Contract Management Agency, the agency responsible for auditing defense contractors' systems, found Lockheed Martin's process did not meet 19 of 32 required guidelines and, in October 2010, withdrew the determination of compliance. While

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acknowledging that Lockheed Martin has made improvements, DCMA in 2012 found the company still deficient on 13 guidelines. EVMS is an important, established tool for tracking costs, controlling schedule, identifying problems early, and providing accurate product status reports. DOD requires its use by major defense suppliers to facilitate good insight and oversight of the expenditure of government dollars.

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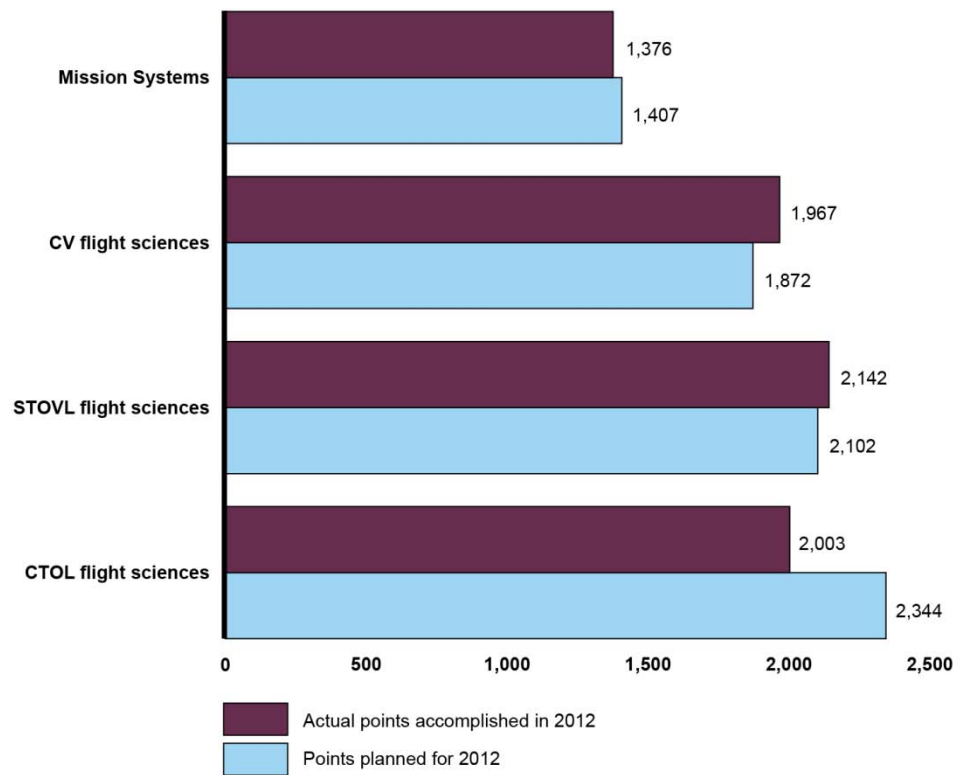
## Development Flight Test Program Made Progress

The F-35 development flight test program also substantially met 2012 expectations with some revisions to original plans. The program exceeded its planned number of flights by 18 percent, although it fell short of its plan in terms of test points flown by about 3 percent, suggesting that the flights flown were not as productive as expected.<sup>7</sup> Test officials had to make several adjustments to plans during the year due to aircraft operating and performance limitations and late releases of software to test. As a result, none of the three variants completed all the 2012 baseline points as originally planned. However, the test team was able to add and complete some test points that had been planned for future years. In this manner, the program was actually able to accomplish more test points in total than planned. Figure 1 compares the total baseline flight test points accomplished in 2012 against the initial plan for each test vehicle.

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<sup>7</sup>Cumulatively since the start of F-35 developmental flight testing in December 2009, the program is ahead of plans by 12 percent for the number of flights and 4 percent for test points flown.

**Figure 1: F-35 Flight Test Points Progress in 2012**



Source: GAO analysis of DOD data.

Notes: This compares baseline points accomplished and planned. It does not include added points from future year plans. CV = carrier-suitable variant, STOVL = short takeoff and vertical landing, and CTOL = conventional takeoff and landing.

Results from flight testing in 2012 included the following:

- Aircraft dedicated to testing mission systems exceeded the number of planned flights and fell just short of accomplishing the total test points planned. Testing supported development of software providing training and initial warfighting capability as well as baseline signature testing. Overall progress in verifying and fielding enhanced capabilities was limited, largely because of late and incomplete software.
- The Navy's F-35C carrier-suitable variant exceeded its number of planned flights and planned test points for 2012. Testing verified the basic flight envelope (demonstrating ranges of speed and altitude), flight with external weapons, and prepared the aircraft for simulated carrier landings. The program also accomplished shore-based tests of

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a redesigned arresting hook (the hook engages the landing wires on aircraft carriers).

- The Marine Corp's F-35B short takeoff and vertical landing variant exceeded the number of flights and test points. It successfully completed the first weapons release, engine air start tests, fuel dump operations, expanded flight envelope with weapons loaded, and radar signature testing. It also tested re-designed air inlet doors in vertical lift operations.
- The Air Force's F-35A conventional takeoff and landing variant accomplished high angle of attack testing, initial weapons separation, and engine air start. It also evaluated flying qualities with internal and external weapons, and expanded the envelope for airspeed and altitude. This variant did not accomplish as many flights as planned and fell short of planned test points by about 15 percent. Operating restrictions and deficiencies in the air refueling system were the main constraints.

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### F-35 Program Made Progress Addressing Significant Technical Risks

Flight, ground, and lab testing has identified significant technical and structural concerns that, if not addressed, would substantially degrade the F-35's capabilities and mission effectiveness. The F-35 program made considerable progress in 2012 to address these major technical risks:

- The helmet mounted display (which provides flight data, targeting, and other sensor data to the pilot) is integral to the mission systems architecture, to reduce pilot workload, and to achieve the F-35's concept of operations. The original helmet mounted display encountered significant technical deficiencies and did not meet warfighter requirements. The program is pursuing a dual path by developing a second, less capable helmet while working to fix the first helmet design. Both helmets are being evaluated and program and contractor officials told us that they have increased confidence that the helmet deficiencies will be fixed. DOD may make a decision as to which helmet to procure in 2013, but the selected helmet is not expected to be integrated into the baseline aircraft until 2015.
- The Autonomic Logistics Information System (ALIS) is an important tool to predict and diagnose maintenance and supply issues, automating logistics support processes and providing decision aids aimed at reducing life cycle sustainment costs and improving force readiness. ALIS is developed and fielded in increments. Limited capability ALIS systems are in use at training and testing locations. More capable versions are being developed and program and contractor officials told us that the program is on track to fix identified shortcomings and field the fully capable system in 2015. Limited

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progress was made in 2012 on developing a smaller, transportable version needed to support unit level deployments to operating locations.

- During 2012, the carrier variant Arresting Hook System was redesigned after the original hook was found to be deficient, which prevented active carrier trials. During shore-based tests, the program accomplished risk reduction testing of a redesigned hook point to inform this new design. The preliminary design review was conducted in August 2012 and the critical design review in February 2013. Flight testing of the redesigned system is slated for late 2013.
- Ground testing also made continued progress in 2012, including structural and durability testing to verify that all three variants can achieve expected life and identify life-limited parts. Over time, testing has discovered bulkhead and rib cracks. The program is testing some redesigned structures and planning other modifications. Officials plan to retrofit test and production aircraft already built and make changes to the production line for subsequent aircraft. Current projections show the aircraft and modifications remain within weight targets.

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### While Software Development Continues to Provide Significant Challenges, Software Management Has Improved

The F-35 software development effort is one of the largest and most complex in DOD history. It is essential to achieve capabilities such as sensor fusion, weapons and fire control, maintenance diagnostics, and propulsion. Recent management actions to refocus software development activities and to implement improvement initiatives appear to be yielding benefits, but software will continue to be a very challenging and high risk undertaking for this program, especially for mission systems. Over time, software requirements have grown in size and complexity and the contractor has taken more time and effort than expected to write computer code, integrate it on aircraft and subsystems, conduct lab and flight tests to verify it works, and to correct defects found in testing.

The aircraft contractor and F-35 program office have recently taken steps to improve software management and output. In addition to completing most work on the first major software block, other significant management actions should enhance future software and mission system outcomes. These actions include:

- starting up and operating a second system integration lab, adding substantial testing and development capability;
- prioritizing and focusing resources on the next block of software and decreasing concurrent work on multiple blocks;
- implementing improvement initiatives recommended by an independent software review; and

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- evaluating the possible deferral of some capabilities, either to later blocks or moving them outside the current F-35 program to follow on development efforts.

Our April 2011 report discussed the need for several of these actions. For instance, we recommended that DOD undertake an independent software review.<sup>8</sup> Subsequently, an independent review was conducted and contractor software managers implemented several improvement initiatives recommended by that review. These are yielding benefits. For example, program officials reported that the time span to fix defects has decreased from 180 days to 55 days, allowing the program to keep better pace even though the number of defects has increased. In addition, the time taken to build and release software to testing has decreased from 187 hours to 30 hours due to new automated processes. Contractor officials currently plan to broaden the assessment's initiatives to other software development efforts, including logistics and training. Our 2011 report also discussed the need to reduce concurrent block work and to evaluate the possible deferral of the most advanced capabilities to future increments; program officials are actively pursuing these areas as discussed above.

These recent management actions are positive and encouraging, but overall, software development activities in 2012 lagged behind plans. Most software code has been developed, but a substantial amount of integration and test work remains before the program can demonstrate full warfighting capability. Software capabilities are developed, tested and delivered in three major blocks and two increments—initial and final—within each block. The status of the three blocks is described below:

- Block 1.0, providing initial training capability, was largely completed in 2012, although some final development and testing will continue. Also, the capability delivered did not fully meet expected requirements relating to the helmet, ALIS, and instrument landing capabilities.
- Block 2.0, providing initial warfighting capabilities and limited weapons, fell behind due to integration challenges and the reallocation of resources to fix block 1.0 defects. The initial increment, block 2A, delivered late and was incomplete. Full release of the final increment, block 2B, has been delayed until November 2013 and

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<sup>8</sup>GAO, *Joint Strike Fighter: Restructuring Places Program on Firmer Footing, but Progress Still Lags*, [GAO-11-325](#) (Washington, D.C.: Apr. 7, 2011).



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won't be complete until late 2015. The Marine Corps is requiring an operational flight clearance from the Naval Air Systems Command before it can declare an initial operational capability (IOC) for its F-35B force. IOC is the target date each service establishes for fielding an initial combat capable force.

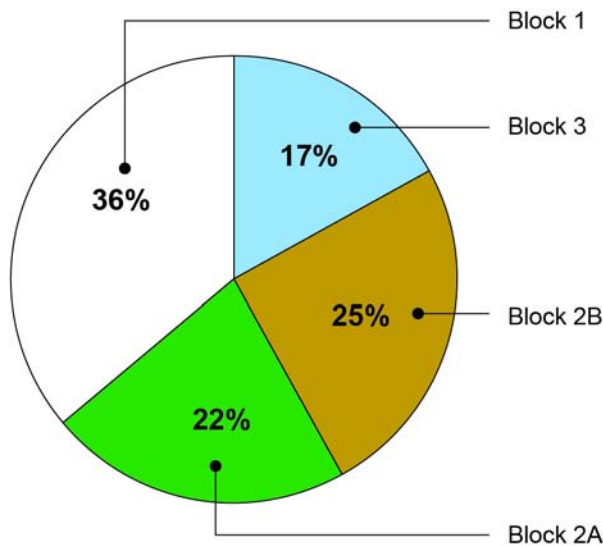
- Block 3.0 providing full warfighting capability, to include sensor fusion and additional weapons, is the capability required by the Navy and Air Force for declaring their respective IOC dates. Thus far, the program has made little progress on block 3.0 software. The program intends initial block 3.0 to enter flight test in 2013, which will be conducted concurrently with the final 15 months of block 2B flight tests. Delivery of final block 3.0 capability is intended to begin nearly 3 years of developmental flight tests in 2014. This is rated as one of the program's highest risks because of its complexity.

In particular, the development and testing of software-intensive mission systems are lagging, with the most challenging work ahead.<sup>9</sup> About 12 percent of mission systems capabilities are validated at this time, up from 4 percent about 1 year ago. Progress on mission systems was limited by contractor delays in software delivery, limited capability in the software when delivered, and the need to fix problems and retest multiple software versions. Further development and integration of the most complex elements—sensor fusion and helmet mounted display—lie ahead. Sensor fusion integrates data from critical subsystems and displays the information to the pilot. Figure 2 depicts the percentage of sensor fusion work associated with each software block. About 36 percent of the sensor fusion work was completed in software block 1. Final verification and closure of remaining fusion requirements through block 3 will not be completed until 2016.

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<sup>9</sup>Mission systems are critical enablers of F-35's combat effectiveness employing next generation sensors with fused information from on-board and off-board systems (i.e. electronic warfare, communication navigation identification, electro-optical target system, electro-optical distributed aperture system, radar, and data links).

**Figure 2: Percent of Sensor Fusion Development in Each Software Block**



Source: GAO analysis of DOD data.

## The Bulk of Testing, Demonstration, and Verification of F-35 Performance Is Ahead

The critical work to test and verify aircraft design and operational performance for the F-35 program is far from complete. Cumulatively since the start of developmental flight testing, the program has flown 2,595 of 7,727 planned flights (34 percent) and accomplished 20,495 of 59,585 test points (34 percent). For development testing as a whole, the program has verified 11.3 percent of the F-35 development contract specifications (349 of 3,094 specifications) through November 2012. Contract specifications include specific design parameters and operating requirements such as speed and range that the F-35 aircraft are expected to meet. Three-fourths of the total contract specifications cannot be fully evaluated, verified, and approved until the final increment of software is released and fully tested. Testing of the final increment is expected to begin in 2014 and continue through 2016.

Initial operational test and evaluation (IOT&E) is scheduled to begin in 2017. This date is dependent on successful completion of development test and evaluation. IOT&E evaluates the combat effectiveness and suitability of the aircraft in an operationally realistic environment. Its successful completion is a prerequisite for DOD's plans to approve the F-35 for full rate production in 2019. Operational testers have raised concerns about F-35's current operational capabilities and suitability,

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readiness for training activities, and the progress of developmental testing. Further, the testing offices in the Office of the Secretary of Defense (OSD) have not approved the latest revision to the test and evaluation master plan because of concerns about the timing and resources available for IOT&E and unacceptable overlap of development with the start of IOT&E. We will continue to monitor the concerns and progress of operational testing during future F-35 reviews.

Achieving key performance parameters are critical to the F-35 meeting the warfighter's operational requirements. They include measures such as range, weapons carriage, mission reliability, and sortie rates. These parameters also cannot be fully verified until the end of IOT&E in 2019. Based on limited information, DOD is currently projecting that the F-35 program is either meeting or close to meeting at least threshold (minimum) performance requirements.

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## After a Slow Start, Aircraft Manufacturing and Deliveries Are Beginning to Catch Up to Plans

While initial F-35 production overran target costs and delivered late, there are several encouraging signs indicating better outcomes in the coming years. Overall, manufacturing and supply operations are improving with the latest data showing labor hours to build the aircraft decreasing, deliveries accelerating, quality measures improving, and parts shortages declining. That said, the program is working through the continuing effects from the F-35's highly concurrent acquisition strategy. For example, the program is continuing to incur substantial costs for rework to fix deficiencies discovered in testing, but the amount per aircraft is dropping. Nevertheless, continuing discoveries in testing will likely drive additional changes to design and manufacturing processes at the same time production rates increase. DOD's substantial reductions in near-term procurement quantities have decreased—but not eliminated—the risk from investing billions of dollars on hundreds of aircraft before testing proves the aircraft design and verifies that its performance and reliability meet requirements.

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## Manufacturing Is Becoming More Efficient

Analyses of labor, parts, and quality data, observations on the manufacturing floor, and discussions with defense and contracting officials provide signs that F-35 manufacturing and supply processes are improving. The aircraft contractor is moving down a steep learning curve, which is a measure that the work force is gaining important experience and that processes are maturing as more aircraft are built. Other indicators of improvement include the following:

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- The decrease in labor hours needed to complete aircraft at the prime contractor's plant as the labor force gains experience. For example, the first Air Force production jet was delivered in May 2011 and required about 149,000 labor hours at the prime's plant to build, while an Air Force jet delivered in December 2012 only required about 94,000 labor hours. Overall, the contractor reported a 37 percent reduction in direct labor during 2012.
  - The improvement in the contractor's labor efficiency rate, a measure of how long it is taking to complete certain work tasks against engineering standards. Labor efficiency on the first production aircraft was 6 percent and improved to 13 percent for the 31st production aircraft. While still low, Defense Contract Management Agency officials stated that the rate should continue to improve with increased production due to work force learning and factory line enhancements.
  - The decrease in span times—the number of calendar days to manufacture aircraft in total and in specific work staging areas. The aircraft contractor is altering assembly line processes to streamline factory flow. As a result, for example, span time in the final assembly area declined by about one-third in 2012 compared to 2011.
  - The increase in factory throughput as the contractor delivered 30 production aircraft in 2012 compared to 9 in 2011. During our plant visit in 2012, we observed an increased level of activity on the manufacturing floor as compared to 2011. The contractor had more tooling in place, had altered and streamlined processes, and had factory expansion plans underway.
  - The decrease in traveled work (work done out of sequence or incomplete items moving to the next work station), parts shortages on the line, and product defects. For example, traveled work declined 90 percent and the defect rate declined almost 80 percent in 2012 compared to 2011. Other quality indicators such as scrap rates and non-conformances also improved from prior years and are trending in a positive direction. These have all been major contributors to past cost increases and schedule delays.
  - The accomplishment of a schedule risk analysis to improve the contractor's master schedule and related schedules. A schedule risk analysis is a comprehensive evaluation that uses statistical techniques to examine the fidelity of schedule estimates and the likelihood of accomplishing work as scheduled. It provides better and timelier insight into program performance to help identify and resolve schedule roadblocks.
  - The improvement in aircraft contractor manufacturing processes, although not fully mature compared to best practice standards. The aircraft contractor is using statistical process control to bring critical manufacturing processes under control so they are repeatable,

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sustainable, and consistently producing parts within quality tolerances and standards. The best practice standard is to have all critical manufacturing processes in control by the start of production. Just over one-third of manufacturing processes are currently judged to be capable of consistently producing quality parts at the best practice standard. The contractor has a plan in place to achieve the best practice standard by the start of full-rate production in 2019. We have observed this quality practice on only a few DOD programs.

Going forward, effective management of the global supply chain is vital to boost production rates to planned levels, to control costs, and maintain quality. The aircraft contractor is developing a global supply chain of more than 1,500 suppliers. Effective supplier management will be critical to efficient and quality manufacturing at higher annual rates. Currently, a relatively small number of suppliers provide most of the material, but that is expected to change in the future, especially as international firms get more of the business. Management of international supplier base presents unique challenges, including (1) differing U.S. and foreign government policies, (2) differences in business practices, and (3) foreign currency exchange rates. These can complicate relationships and hinder effective supply chain integration.

The aircraft contractor is implementing stringent supplier quality management practices. For example, Lockheed Martin officials assess the overall performance of key component suppliers against program goals for production affordability, contract cost growth, delivery times, part shortage occurrences, and field performance, as well as the number of corrective action reports filed against the supplier. In total, key component suppliers are assessed and rated across 23 measures, as applicable and the contractor works with suppliers to improve performance.

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### Production Costs Are Trending Toward Targets and Aircraft Deliveries Are Accelerating

As discussed earlier, aircraft labor hours to build aircraft are decreasing with more experience and the program is moving down the learning curve as projected. The fifth annual low rate initial production (LRIP) contract was recently negotiated with cost targets reflecting additional gains in efficiency. DOD and contractor officials also expressed confidence that contracts for the 6th and 7th annual buys will be negotiated by this summer and reflect similar performance. The first four LRIP contracts, however, over-ran their target costs, in total by \$1.2 billion. According to program documentation, the government's share of the total overrun is about \$756 million under the sharing incentive provisions in these contracts. Cost increases range from 6.5 percent to 16.1 percent more

than negotiated costs. LRIP 4, the largest by dollar and number of aircraft, had the smallest percent increase in cost, indicating better performance. Contract costs and increases are summarized in table 3.

**Table 3: Procurement Contract Costs as of September 2012**

Dollars in millions

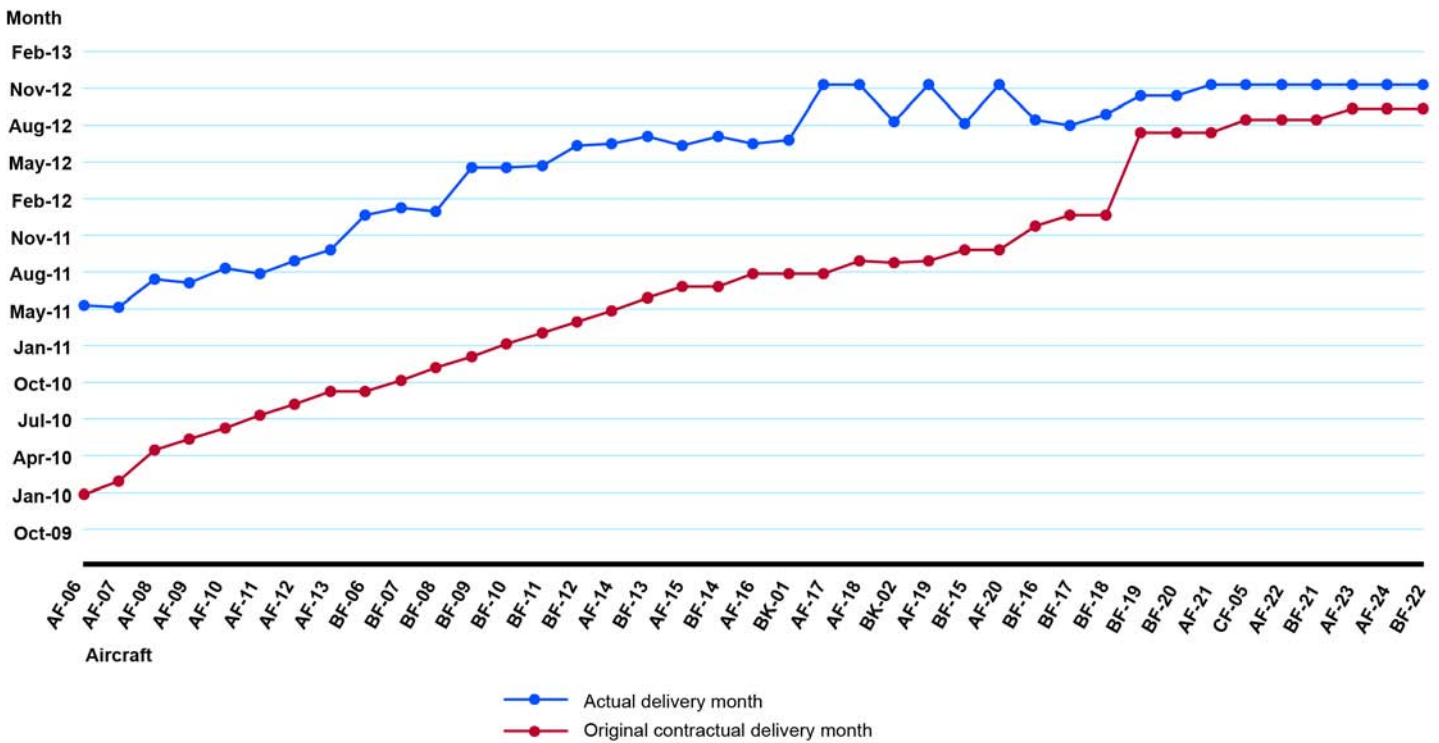
<b>Contract</b>	<b>Number of aircraft</b>	<b>Contract cost at award</b>	<b>Current contract cost estimate</b>	<b>Cost increase</b>	<b>Percent increase</b>
LRIP 1	2	\$511.7	\$561.6	\$49.9	9.7
LRIP 2	12	2,349.6	2,671.6	322.0	13.7
LRIP 3	17	3,178.7	3,691.0	512.3	16.1
LRIP 4	32	5,035.9	5,362.5	326.6	6.5
<b>Total</b>	<b>63</b>	<b>\$11,075.9</b>	<b>\$12,286.7</b>	<b>\$1,210.8</b>	<b>10.9</b>

Source: GAO analysis of DOD data.

Note: Total aircraft includes 58 for the United States and 5 for international partners.

The contractor has delivered 39 aircraft under LRIP contracts through the end of December 2012—nine in 2011 and 30 in 2012. Figure 3 tracks actual delivery dates against the dates specified in the contracts. Deliveries were late an average of 11 months compared to the contracted dates, but the data shows that the delivery rate has improved considerably. For example, the first two production aircraft were late 16 and 15 months, respectively, whereas the last two delivered were each 2 months late. Fluctuations in some deliveries during mid-2012 are impacts from the labor strike last summer that the contractor does not expect to continue. Other factors contributing to late deliveries include design changes to the aircraft; traveled work; scrap, repair, and rework hours; and parts shortages.

**Figure 3: F-35 Deliveries Compared to Contract Dates**



Source: GAO analysis of DOD data.

Note: The numbered aircraft are in order of delivery. AF= U.S. Air Force F-35A, BF = U.S. Marine Corps F-35B, CF = U.S. Department of the Navy F-35C; and BK = United Kingdom F-35B.

In addition to contract cost overruns, the program is incurring substantial costs to retrofit (rework) produced aircraft needed to fix deficiencies discovered in testing. These costs are largely attributable to the substantial concurrency, or overlap, between testing and manufacturing activities. The F-35 program office projects rework costs of about \$900 million to fix the aircraft procured on the first four annual procurement contracts. On average, rework adds about \$15.5 million to the price of each of the 58 U.S. aircraft under these contracts.

Substantial rework costs are forecast to continue through the 10th annual contract (fiscal year 2016 procurement), but at decreasing amounts annually and on each aircraft. The program office projects about \$827 million more to rework aircraft procured under the next 6 annual contracts. Government liability for these costs depends on share ratios to be negotiated. The government and Lockheed Martin reached agreement under the LRIP 5 contract that costs for known changes due to

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concurrency will be shared 50/50. Other cost overruns under this contract will be shared 55/45 until the contract ceiling is reached, at which point the contractor assumes total responsibility for overruns. The lagging cost and schedule performance on the first four production contracts and the high costs of rework can be largely attributed to the continuing effects of the F-35's highly concurrent acquisition strategy. The program started manufacturing aircraft before designs were stable, before establishing mature manufacturing processes, and before sufficiently testing the design and aircraft performance. A November 2011 report on concurrency by senior level DOD officials confirms these observations. The report states that F-35 testing continues to find technical issues with significant design and production impacts and requiring rework on produced aircraft. It expresses a lack of confidence in the design stability that was lower than expected given the quantities of aircraft procured and potential for more rework costs.<sup>10</sup>

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**Aircraft Design Changes  
Continue to Impact  
Efficiency and Add to Risk**

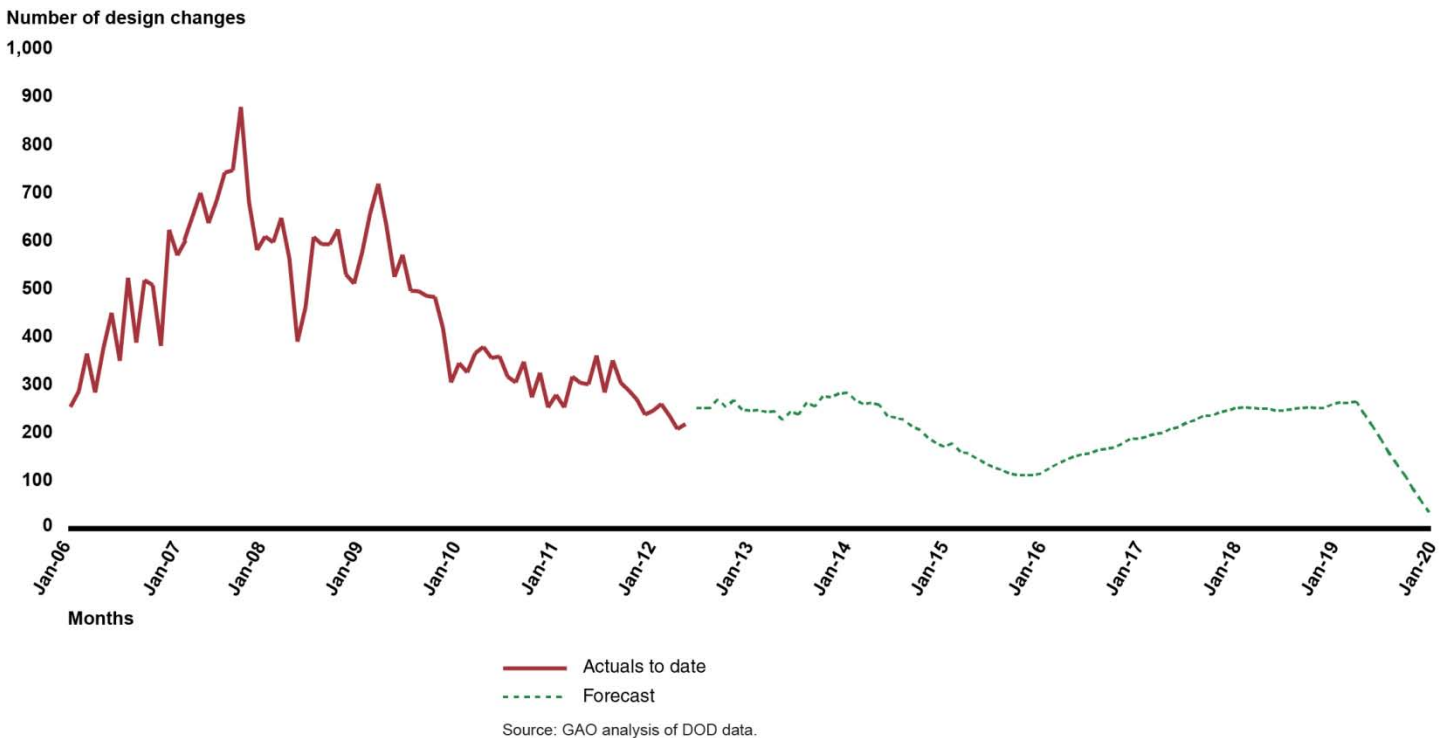
Even with the positive trends in manufacturing, cost, and schedule discussed above, the government continues to incur risk by procuring large quantities of aircraft with the majority of testing still ahead. The contractor continues to make major design and tooling changes and alter manufacturing processes concurrent with development testing. Engineering design changes from discoveries during manufacturing and testing are declining in number, but are still substantial and higher than expected from a program this far into production. With extensive testing ahead, discoveries in testing will drive more design changes, possibly impacting manufacturing processes and the supplier base. Figure 4 graphically depicts monthly engineering change "traffic." The forecast indicates that about one-third of projected design changes in total are to come and will hover around 200 per month through the end of system development, initial operational testing, and start of full rate production in 2019.

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<sup>10</sup>*F-35 Joint Strike Fighter Concurrency Quick Look Review*, Office of the Undersecretary of Defense for Acquisition, Technology and Logistics, November 29, 2011.



**Figure 4: F-35 Engineering Design Changes**

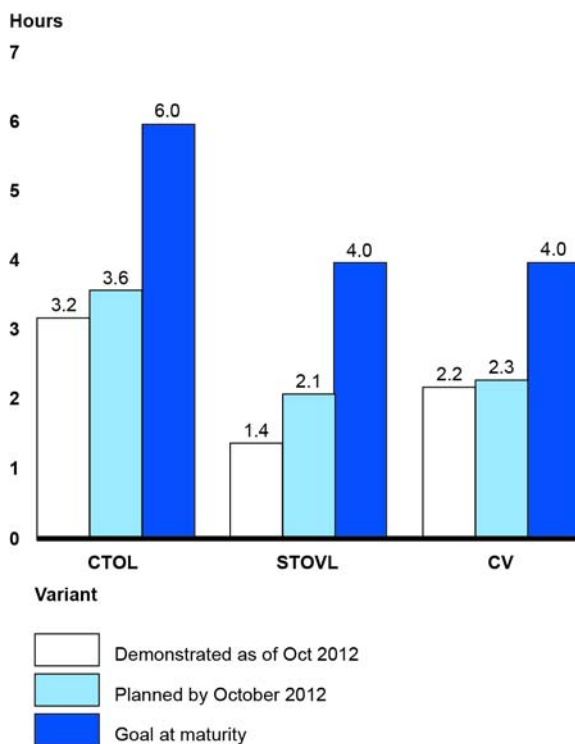


Demonstrating the reliability of a system is another indicator that the design is stable and ready for production. During system acquisition, reliability growth improvements should occur over time as problems are identified, tested, and fixed, usually through design changes and manufacturing process improvements. We have reported in the past that it is important to demonstrate that the system reliability is on track to meet goals before production begins as changes after production commences can be inefficient and costly.<sup>11</sup> One key indicator of F-35 reliability is the mean flying hours between failures, that is, the average time an aircraft can fly before a maintenance action is required to repair a component or system that is not performing as designed. Figure 5 projects F-35 performance on this indicator compared to 2012 plans and eventual

<sup>11</sup>GAO, *Best Practices: Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes*, [GAO-02-701](#) (Washington, D.C.: July 15, 2002).

goals. Compared to data from one year ago, each variant demonstrated some reliability growth in 2012, but each is lagging behind its plan. The Marine Corps' STOVL demonstrated the biggest increase—from 0.5 hours in 2011 to 1.4 hours currently—but it is also the furthest behind plans. We also note that the rates planned by October 2012 were little changed from those established for October 2011.<sup>12</sup>

**Figure 5: Mean Flying Hours between Failures**



Source: GAO analysis of DOD data.

DOD is investing billions of dollars on hundreds of aircraft before the design is stable, testing proves that it works and is reliable, and manufacturing processes mature to where aircraft can be produced in quantity to cost and schedule targets. The department's substantial reductions in procurement quantities in the past few years lowered this

<sup>12</sup>GAO-12-437.

risk, but did not eliminate it.<sup>13</sup> DOD has already invested about \$28 billion in procuring 121 aircraft through the 2012 buy (the 6th annual procurement lot). According to the new acquisition baseline and flight test schedule, DOD will procure 289 aircraft for \$57.8 billion before the end of developmental flight testing (see table 4).

**Table 4: F-35 Procurement Investments and Flight Test Progress**

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Cumulative procurement (then-year dollars in billions)	\$0.8	\$3.5	\$7.1	\$14.3	\$21.3	\$27.6	\$33.8	\$40.1	\$47.9	\$57.8	\$69.0
Cumulative aircraft procured	2	14	28	58	90	121	150	179	223	289	365
Percent total flight test points completed	-	<1%	<1%	2%	9%	22%	34%	54%	74%	91%	100%

Source: GAO analysis of DOD data.

Notes: Years listed denote fiscal years. Flight test data reflects the percentage of total flight test points completed in time to inform the next year's procurement decision. For example above, the F-35 program accomplished about 22 percent of total planned flight test points through the end of calendar year 2011 that could help inform the fiscal year 2012 procurement decision. The program intends to complete developmental flight test points in 2016 and would be in a position to fully support the 2017 procurement buy.

## Costs and Funding for Acquisition and Sustainment Remain Very Challenging Moving Forward

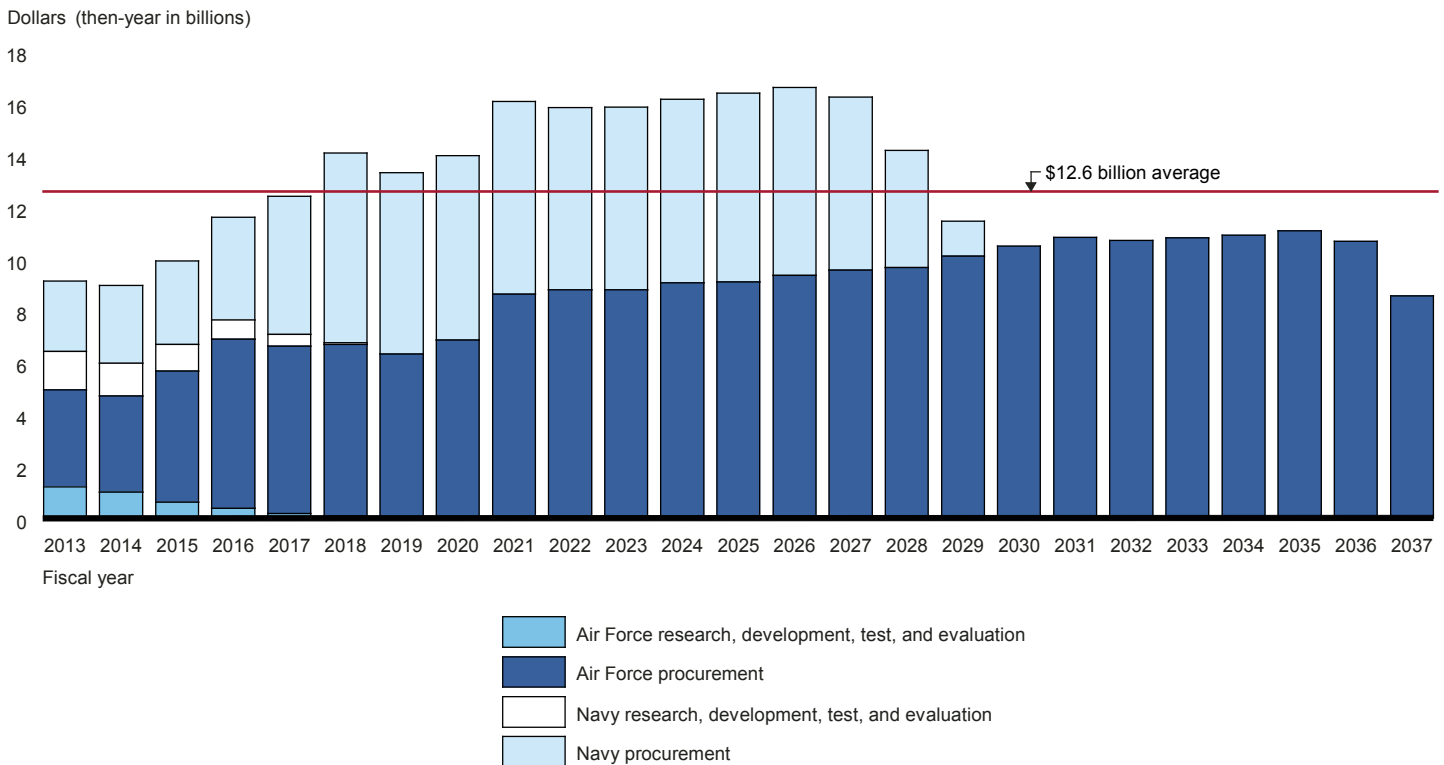
Ensuring that the acquisition costs of the F-35 are affordable so that aircraft can be bought in the quantities and time required by the warfighter will be of paramount concern to the Congress, U.S. military, and international partners. Annual acquisition funding requirements for the United States currently average \$12.6 billion per year through 2037. Once acquired, the current forecasts of life cycle sustainment costs for the F-35 fleet are considered unaffordable by defense officials. Efforts are under way to try and lower annual operating and support costs. Uncertainties and delays in the F-35 program are forcing new plans for recapitalizing fighter forces and the military services are incurring increased costs to buy, modify, and sustain legacy fighters.

<sup>13</sup>Since 2005, a recurring theme in our body of work on the F-35 has been a concern about this substantial concurrency and the risks it poses to achieving good program outcomes. We previously recommended in several reports that annual procurement quantities be reduced to provide more time for testing to verify aircraft design and performance (refer to Appendix I).

## Acquiring F-35 Aircraft at Required Annual Quantities Will Be Expensive

The March 2012 acquisition program baseline incorporates the department's positive restructuring actions since 2010. These actions place the F-35 program on firmer footing, but aircraft are expected to cost more and deliveries to warfighters will take longer than in previous baselines. In terms of acquisition funding requirements, the new baseline projects total development and procurement budget requirements of \$316 billion from 2013 through 2037. Figure 6 shows these budget projections. The rebaselined program will require an average of \$12.6 billion annually through 2037, an unprecedented demand on the defense procurement budget. Maintaining this level of sustained funding will be difficult in a period of declining or flat defense budgets and competition with other "big ticket items" such as the KC-46 tanker and a new bomber program.

**Figure 6: F-35 Program Budgeted Development and Procurement Funding Requirements, Fiscal Years 2013-2037**



Source: GAO analysis of DOD data.

Note: Development and procurement of the Marine Corps variant is included in the Department of the Navy budget accounts.

When approving the new 2012 program baseline, the acting Undersecretary of Defense for Acquisition, Technology, and Logistics

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established affordability unit cost targets for each variant to be met by the start of full-rate production in 2019.<sup>14</sup> To meet these targets, the program will have to reduce unit costs by about 26 percent (STOVL), 35 percent (CTOL), and 39 percent (CV) from the unit costs in the fiscal year 2012 budget request. Our analysis indicates that these targets are achievable if the future year prices and quantities used to construct the new baseline are accurate.

Some international partners are also expressing concern about F-35 prices and schedule delays. Besides the consequences for international cooperation and fighter force commonality, there are at least two other important financial impacts. First, U.S. future budgets assume the financial quantity benefits of partners purchasing at least 697 aircraft. Second, the current procurement profile for the F-35 projects a rapid buildup in partner buys—195 aircraft through 2017 that comprise about half the total production during the 5-year period 2013 through 2017. If fewer aircraft are procured in total or in smaller annual quantities, unit costs paid by the U.S. and partners will likely rise.

To better understand the potential impacts on prices from changes in quantities, OSD's Cost Assessment and Program Evaluation (CAPE) office did a sensitivity analysis to forecast impacts on F-35 average procurement unit costs assuming various quantities purchased by the United States and international partners. For example, if the United States bought its full quantity of 2,443 aircraft and the partners did not buy any aircraft, CAPE calculated that the average unit cost would increase by 6 percent. If the United States bought 1,500 aircraft and the partners bought their expected quantity of 697, unit costs would rise by 9 percent. If the United States bought 1,500 and the partners 0, unit costs would rise 19 percent.

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## Controlling Sustainment Costs Is a Major Concern

In addition to the costs for acquiring aircraft, significant concerns and questions persist regarding the cost to operate and sustain F-35 fleets over the coming decades. The current sustainment cost projection by CAPE for all U.S. aircraft, based on an estimated 30 year service life,

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<sup>14</sup>Affordability targets were established for the unit recurring flyaway costs. These are budgeted procurement costs associated with buying the aircraft itself, including the airframe, engine, electronics, and armament. Targets do not include procurement of non-recurring production items, ancillary ground support equipment, and spares.

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exceeds \$1 trillion. This raises long-term affordability concerns for the military services and international partners. F-35 operating and support costs (O&S) are currently projected to be 60 percent higher than those of the existing aircraft it will replace. Using current program assumptions of aircraft inventory and flight hours, CAPE recently estimated annual O&S costs of \$18.2 billion for all F-35 variants compared to \$11.1 billion spent in 2010 to operate and sustain the legacy aircraft. DOD officials have declared that O&S costs of this magnitude are unaffordable and are actively engaged in evaluating opportunities to reduce F-35 life-cycle sustainment costs, such as basing and infrastructure reductions, competitive sourcing, and reliability improvements.

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### F-35 Delays Have Increased Recapitalization Costs for Existing Fighters

IOC dates are critical milestones for the F-35 program because these are the target dates for fielding initial combat capable forces as required by the warfighters when justifying the need for the new weapon system. As shown earlier in table 1, these dates have slipped over time and have not been reset in the new baseline. The military services have been reassessing their needs for several years and have deferred setting new target dates for acquiring warfighting capabilities until operational test plans are better understood. Based on service criteria espoused earlier in the program, it would appear that the earliest possible IOC dates are now 2015 for the Marine Corps and 2017 for the Air Force and Navy.

Because of F-35 delays and uncertainties, the military services are extending the service life of legacy aircraft to bridge the gap in F-35 deliveries and mitigate projected shortfalls in fighter aircraft force requirements. In November 2012, we reported current cost estimates of almost \$5 billion (in 2013 dollars) to extend the service life of 300 Air Force F-16s and 150 Navy F/A-18s, with additional quantities possible if needed to maintain inventory levels.<sup>15</sup> At the Congress's behest, the Navy is also buying 41 new F/A-18 E/F Super Hornets at a budgeted cost of about \$3.1 billion (then-year dollars). The services will incur additional future sustainment costs to support these new and extended-life aircraft. F-35 delays and uncertainties continue to make it difficult for the services to establish and implement retirement schedules for existing fleets and to

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<sup>15</sup>GAO, *Fighter Aircraft: Better Cost Estimates Needed for Extending the Service Life of Selected F-16s and F-18s*, [GAO-13-51](#) (Washington, D.C.: Nov. 15, 2012).

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develop firm basing and manpower plans for housing and supporting future forces.

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## Concluding Observations

Overall, the F-35 Joint Strike Fighter program is now moving in the right direction after a long, expensive, and arduous learning process. It still has tremendous challenges ahead. The program must fully validate design and operational performance against warfighter requirements, while, at the same time, making the system affordable so that the United States and partners can acquire new capabilities in the quantity needed and can then sustain the force over its life cycle. Recent restructuring actions have improved the F-35's prospects for success, albeit at greater costs and further delays. Many of the restructuring actions—more time and resources for development flight testing, reduced annual procurements, the recognition of concurrency risks, independent cost and software assessments, and others—are responsive to our past recommendations. Recent management initiatives, including the schedule risk analysis and the software assessment, also respond to prior recommendations. As a result, we are not making new recommendations in this report. DOD and the contractor now need to demonstrate that the F-35 program can effectively perform against cost and schedule targets in the new baseline and deliver on promises. Until then, it will continue to be difficult for the United States and international partners to confidently plan, prioritize, and budget for the future; retire aging aircraft; and establish basing plans with a support infrastructure. Achieving affordability in annual funding requirements, aircraft unit prices, and life-cycle operating and support costs will in large part determine how many aircraft the warfighter can ultimately acquire, sustain, and have available for combat.

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## Agency Comments and Our Evaluation

DOD provided comments on a draft of this report, which are reprinted in appendix III. DOD concurred with the report's findings and conclusions.

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We are sending copies of this report to appropriate congressional committees; the Secretary of Defense; the Secretaries of the Air Force, Army, and Navy; the Commandant of the Marine Corps; and the Director of the Office of Management and Budget. The report is available at no charge on the GAO website at <http://www.gao.gov>.

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If you or your staff have any questions about this report, please contact me at ((202) 512-4841 or [sullivanm@gao.gov](mailto:sullivanm@gao.gov). Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Staff members making key contributions to this report are listed in Appendix IV.

A handwritten signature in black ink, appearing to read 'Michael J. Sullivan', with a stylized, flowing script.

Michael J. Sullivan  
Director  
Acquisition and Sourcing Management



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*List of Committees*

The Honorable Carl Levin  
Chairman  
The Honorable James Inhofe  
Ranking Member  
Committee on Armed Services  
United States Senate

The Honorable Dick Durbin  
Chairman  
The Honorable Thad Cochran  
Ranking Member  
Subcommittee on Defense  
Committee on Appropriations  
United States Senate

The Honorable Howard P. McKeon  
Chairman  
The Honorable Adam Smith  
Ranking Member  
Committee on Armed Services  
House of Representatives

The Honorable C.W. Bill Young  
Chairman  
The Honorable Pete Visclosky  
Ranking Member  
Subcommittee on Defense  
Committee on Appropriations  
House of Representatives

# Appendix I: Prior GAO Reports and DOD Responses

GAO report	Est. dev. costs dev. length aircraft unit cost	Key program event	Primary GAO message	DOD response and actions
2001 <a href="#">GAO-02-39</a>	\$34.4 Billion 10 years \$69 Million	Start of system development and demonstration approved.	Critical technologies needed for key aircraft performance elements not mature. Program should delay start of system development until critical technologies mature to acceptable levels.	DOD did not delay start of system development and demonstration stating technologies were at acceptable maturity levels and will manage risks in development.
2005 <a href="#">GAO-05-271</a>	\$44.8 Billion 12 years \$82 Million	The program undergoes re-plan to address higher than expected design weight, which added \$7 billion and 18 months to development schedule.	We recommended that the program reduce risks and establish executable business case that is knowledge-based with an evolutionary acquisition strategy.	DOD partially concurred but did not adjust strategy, believing that its approach is balanced between cost, schedule and technical risk.
2006 <a href="#">GAO-06-356</a>	\$45.7 Billion 12 years \$86 Million	Program sets in motion plan to enter production in 2007 shortly after first flight of the non-production representative aircraft.	The program planned to enter production with less than 1 percent of testing complete. We recommended program delay investing in production until flight testing shows that F-35 performs as expected.	DOD partially concurred but did not delay start of production because it believed the risk level was appropriate.
2007 <a href="#">GAO-07-360</a>	\$44.5 Billion 12 years \$104 Million	Congress reduced funding for first two low-rate production buys thereby slowing the ramp up of production.	Progress was being made but concerns remained about undue overlap in testing and production. We recommended limits to annual production quantities to 24 a year until flying quantities are demonstrated.	DOD non-concurred and felt that the program had an acceptable level of concurrency and an appropriate acquisition strategy.
2008 <a href="#">GAO-08-388</a>	\$44.2 Billion 12 years \$104 Million	DOD implemented a Mid-Course Risk Reduction Plan to replenish management reserves from about \$400 million to about \$1 billion by reducing test resources.	We believed new plan increased risks and DOD should revise it to address testing, management reserves, and manufacturing concerns. We determined that the cost estimate was not reliable and that a new cost estimate and schedule risk assessment is needed.	DOD did not revise risk plan or restore testing resources, stating that it will monitor the new plan and adjust it if necessary. Consistent with a report recommendation, a new cost estimate was eventually prepared, but DOD refused to do a risk and uncertainty analysis.

**Appendix I: Prior GAO Reports and DOD Responses**

<b>GAO report</b>	<b>Est. dev. costs dev. length aircraft unit cost</b>	<b>Key program event</b>	<b>Primary GAO message</b>	<b>DOD response and actions</b>
2009 <a href="#">GAO-09-303</a>	\$44.4 Billion 13 years \$104 Million	The program increased the cost estimate and adds a year to development but accelerated the production ramp up. Independent DOD cost estimate (JET I) projects even higher costs and further delays.	Moving forward with an accelerated procurement plan and use of cost reimbursement contracts is very risky. We recommended the program report on the risks and mitigation strategy for this approach.	DOD agreed to report its contracting strategy and plans to Congress and conduct a schedule risk analysis. The program completed the first schedule risk assessment with plans to update semi-annually. The Department announced a major restructuring reducing procurement and moving to fixed-price contracts.
2010 <a href="#">GAO-10-382</a>	\$49.3 Billion 15 years \$112 Million	The program was restructured to reflect findings of recent independent cost team (JET II) 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 inhibit the program's ability to meet needs on time. We recommended the program complete a full comprehensive cost estimate and assess warfighter and IOC requirements. We suggest 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 are currently reviewing capability requirements as we recommended.
2011 <a href="#">GAO-11-325</a>	\$51.8 Billion 16 years \$133 Million	Restructuring continued with additional development cost increases; schedule growth; further reduction in near-term procurement quantities; and decreased the rate of increase for future production. The Secretary of Defense placed the STOVL variant on a 2 year probation; decoupled STOVL from the other variants; and reduced STOVL production plans for fiscal years 2011 to 2013.	The restructuring actions are positive and if implemented properly, should lead to more achievable and predictable outcomes. Concurrency of development, test, and production is substantial and provides risk to the program. We recommended the program maintain funding levels as budgeted; establish criteria for STOVL probation; and conduct an independent review of software development, integration, and test processes.	DOD concurred with all three of the recommendations. DOD lifted STOVL probation, citing improved performance. Subsequently, DOD further reduced procurement quantities, decreasing funding requirements through 2016. The initial independent software assessment began in and ongoing reviews are planned through 2012.

**Appendix I: Prior GAO Reports and DOD Responses**

<b>GAO report</b>	<b>Est. dev. costs dev. length aircraft unit cost</b>	<b>Key program event</b>	<b>Primary GAO message</b>	<b>DOD response and actions</b>
2012 <a href="#">GAO-12-437</a>	\$55.2 Billion 18 years \$137 Million	The program established a new acquisition program baseline and approved the continuation of system development, increasing costs for development and procurements and extending the period of planned procurements by 2 years.	Extensive restructuring places the program on a more achievable course. Most of the program's instability continues to be concurrency of development, test, and production. We recommend the Cost Assessment and Program Evaluation office conduct an analysis on the impact of lower annual funding levels; F-35 program office conducts an assessment of the supply chain and transportation network.	DOD partially concurred with conducting an analysis on the impact of lower annual funding levels and concurred with assessing the supply chain and transportation network.

Source: GAO.

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# Appendix II: Scope and Methodology

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To evaluate F-35 Joint Strike Fighter program performance during calendar year 2012, we compared key management objectives on testing, training, contracting, cost and schedule activities to progress made during the year on each objective. On development flight testing, we interviewed F-35 program office, the aircraft contractor, and the office of the Director of Operational Test and Evaluation (DOT&E) officials on development test plans and results against expectations. We obtained and analyzed data on flights and test points, both planned and accomplished during 2012, and also compared progress against the total plans to complete. We obtained officials' comments and reports on technical risks. We evaluated progress made and work to complete on major technical risks, including the helmet, logistics system, carrier arresting hook, and structural cracks. We reviewed status of software development and integration, contractor management improvement initiatives, issues on data fusion, and the impacts of late releases of software on the test program. We reviewed key documents related to this objective, including DOT&E's annual F-35 assessment, the Joint Strike Fighter Operational Test Team Report, and the Independent Software Assessment.

To assess manufacturing and supply performance indicators, production results, and design changes, we obtained and analyzed manufacturing contract cost, aircraft delivery, and work performance data through the end of calendar year 2012 to assess progress against plans. We reviewed data and briefings provided by the program office, aircraft contractor, and the Defense Contract Management Agency (DCMA) in order to identify issues and assess impacts on supplier performance, costs of rework, manufacturing labor and quality data, and maturity of design and manufacturing process controls. We also determined reasons for manufacturing cost overruns and delivery delays, discussed program and contractor plans to improve, and projected the impact on development and operational tests. We interviewed contractor and DCMA officials to discuss the Earned Value Management System (EVMS) and Lockheed's progress in improving its system. We did not conduct our own analysis of EVMS since the system has not yet been re-validated by DCMA. We also reviewed the Office of the Secretary of Defense's F-35 Joint Strike Fighter Concurrency Quick Look Review.

To determine acquisition and sustainment costs going forward, we received briefings by program and contractor officials and reviewed financial management reports, budget briefings annual Selected Acquisition Reports, monthly status reports, performance indicators, and other data through the end of calendar year 2012. We identified changes in cost and schedule, and obtained officials' reasons for these changes.

We reviewed total program funding requirements in the Selected Acquisition Reports since the program's inception and analyzed fiscal year 2013 President's Budget data. We used this data to project annual funding requirements through the expected end of the F-35 acquisition in 2037. We obtained and discussed the life cycle operating and support cost projections made by the Cost Assessment and Program Evaluation office and discussed future plans of the Department to try and reduce life cycle sustainment costs.

In performing our work, we obtained financial data, programmatic information, and interviewed officials from the F-35 Joint Program Office, Arlington, Virginia; Lockheed Martin Aeronautics, Fort Worth, Texas; Defense Contract Management Agency, Fort Worth, Texas; and the Under Secretary of Defense for Acquisition, Technology, and Logistics, the Director of Operational Test and Evaluation, and the Cost Assessment and Program Evaluation office, all organizations within the Office of the Secretary of Defense in Washington, D.C.

We assessed the reliability of DOD and Contractor data by: reviewing existing information about the data, and interviewing agency officials knowledgeable about the data. We determined that the data were sufficiently reliable for the purposes of this report. We conducted this performance audit from August 2012 to March 2013 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.

# Appendix III: Comments from the Department of Defense



ACQUISITION

ASSISTANT SECRETARY OF DEFENSE  
3015 DEFENSE PENTAGON  
WASHINGTON, DC 20301-3015

MAR 11 2013

Mr. Michael J. Sullivan  
Director, Acquisition and Sourcing Management  
U.S. Government Accountability Office  
441 G Street, N.W.  
Washington, DC 20548

Dear Mr. Sullivan:

This is the Department of Defense (DoD) response to the Government Accountability Office (GAO) Draft Report, GAO-13-309, "F-35 JOINT STRIKE FIGHTER: Current Outlook is Improved, but Long Term Affordability is a Major Concern," dated February 20, 2013 (GAO Code 121080).

The DoD values the GAO's analysis of the F-35 program. We agree with GAO's concluding observations and appreciate the recognition of the Department's responsiveness to previous recommendations. The Department will continue to be supportive of the annual GAO review of the F-35 program.

Sincerely,

Katrina McFarland

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# Appendix IV: GAO Contact and Staff Acknowledgments

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## GAO Contact

Michael Sullivan (202) 512-4841 or [sullivanm@gao.gov](mailto:sullivanm@gao.gov)

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## Acknowledgments

In addition to the contact name above, the following staff members made key contributions to this report: Bruce Fairbairn, Assistant Director; Marvin Bonner; Dr. W. Kendal Roberts; Erin Stockdale; Jungin Park; Megan Porter and John Lack.



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# Related GAO Products

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Joint Strike Fighter: DOD Actions Needed to Further Enhance Restructuring and Address Affordability Risks. [GAO-12-437](#). Washington, D.C.: June 14, 2012.

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