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Report to Congressional Committees

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WEAPON SYSTEMS ANNUAL ASSESSMENT

Knowledge Gaps Pose Risks to Sustaining Recent Positive Trends

GAO-18-360SP

A Report to Congressional Committees

GAO Highlights

Highlights of GAO-18-360SP

Weapon Systems Annual Assessment

Knowledge Gaps Pose Risks to Sustaining Recent Positive Trends

While programs initiated since 2010—when sweeping acquisition reforms were implemented—have stayed within their cost estimates better than earlier programs, most continue to proceed without the key knowledge essential to good acquisition outcomes. Historically, this has translated to schedule delays, cost growth, and other inefficiencies that have beset DOD programs for years.

This report provides observations on:

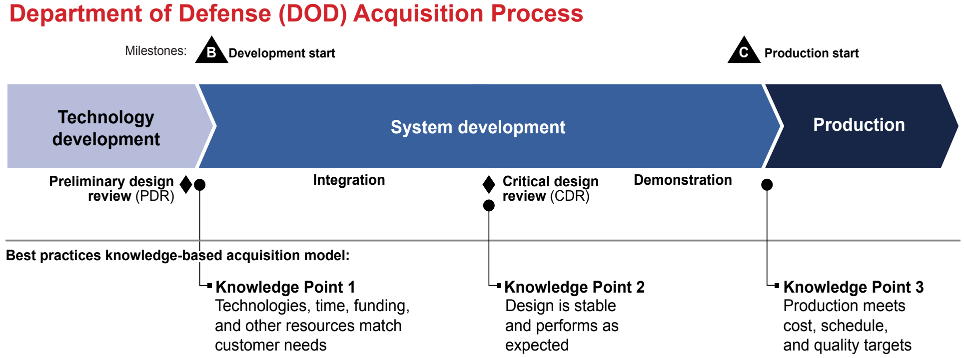
1. cost and schedule performance for DOD's 2017 portfolio of 86 programs that provide annual acquisition reports to congress;
2. implementation of acquisition reforms among 57 individual weapon programs not in serial production or with new capabilites; and
3. knowledge that these 57 programs attained at key points in the acquisition process.

GAO also makes observations specific to two sets of programs: those initiated since 2010 and before 2010.

This special report, GAO's 16th annual assessment of the Department of Defense's (DOD) $1.66 trillion portfolio of 86 major weapon systems acquisition programs, examines changes in the portfolio since 2016, including DOD's progress implementing acquisition reforms. Drawing from questionnaire data, this report also offers a quick look at the cost, schedule, and performance of 57 individual weapon programs.

Since DOD began to implement acquisition reforms 8 years ago, new defense weapon systems programs have done a better job staying within budget estimates than their predecessors. However, most programs continue to proceed without the key knowledge essential to good acquisition outcomes. As the figure shows, DOD's major acquisition programs proceed through three phases—technology development, system development, and production—that align with three key points for demonstrating knowledge.

Department of Defense (DOD) Acquisition Process

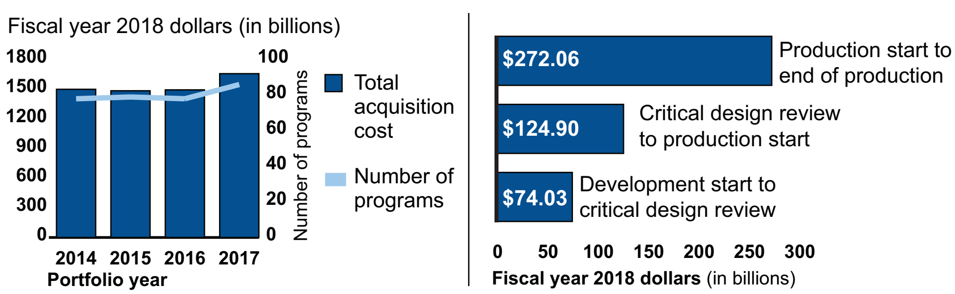


Source: GAO analysis of DOD-provided data, DOD Instruction 5000.02, and best practices. | GAO-18-360SP

DOD's 2017 Portfolio Has Grown in Cost and Size; Programs Initiated since 2010 Demonstrated Better Cost Performance

DOD's 2017 portfolio of major weapon programs has grown in cost and size. GAO's analysis shows that programs initiated since 2010 had better cost performance between 2016 and 2017 than the rest of the portfolio—an estimated $5.6 billion decrease versus a $60.3 billion increase. It is too early to say whether this performance will continue and curb future cost growth. Future cost outcomes hinge on how these programs perform once they enter production, when cost growth is most prevalent. (See figure.)

DOD's Portfolio Increased in Cost and Size; Most Cost Growth Occurred after Production Start



Source: GAO analysis of Department of Defense data. | GAO-18-360SP

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Programs that Implemented Acquisition Strategies to Promote Competition for Contracts Reported Decreased Total Acquisition Cost Estimates

Programs that implemented acquisition strategies to promote competition, including competitive award of contracts, reported decreases in total acquisition cost estimates as compared to others. In 2010, DOD implemented reforms including some aimed at increasing competition to introduce greater affordability and efficiency. Subsequently, GAO observed that individual programs have taken steps to implement acquisition strategies that promote competition. Of the programs in this year's assessment that awarded development, test, or production contracts, 61 percent did so competitively.

Knowledge-based Acquisition Practices Can Lead to Better Cost and Schedule Outcomes, but Programs Continue to Not Fully Implement Them

As in previous assessments, DOD programs continue to not fully implement knowledge-based acquisition practices. GAO observed that most of the 45 current programs have proceeded into system development, through critical design reviews, and into production without completing key knowledge-based practices associated with each of these three points. (See table.) Further, almost all of the 12 future programs GAO reviewed, not yet in DOD's portfolio, reported that they do not currently plan to fully meet all applicable practices when starting system development.

DOD Programs Continue to Not Fully Implement Key Knowledge-Based Acquisition Practices

Practices Associated with the Three Key Knowledge Points (KP)	Thirty-seven programs GAO previously assessed that had completed the KP	Eight programs GAO assessed in 2018 that recently completed the KP
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	◐	●
Demonstrate all critical technologies are in form, fit, and, function within a realistic environment	○	●
Completed preliminary design review before system development start	◐	○
Release at least 90 percent of design drawings to manufacturing	○	●
Test a system-level integrated prototype	○	○
Demonstrate critical manufacturing processes are in statistical control	○	○
Demonstrate critical processes on a pilot production line	◐	●
Test a production-representative prototype in its intended environment	○	◐

Programs completing each best practice ● 75 - 100 percent ◐ 50 - 74 percent ○ 0 - 49 percent

This lack of knowledge and the effects it can have throughout a program's acquisition life cycle can increase the risk of undesirable cost and schedule outcomes. Based on GAO's exploratory statistical analysis of 15 programs in production, the major DOD acquisition programs that completed one or more of three specific knowledge-based acquisition practices, among eight key practices GAO evaluated, had significantly lower cost and schedule growth than those that did not. These three practices were (1) demonstration that all critical technologies were very close to final form, fit, and function, within a relevant environment, before starting development; (2) completion of a preliminary design review prior to starting development; and (3) release of at least 90 percent of design drawings by critical design review.

Contents

Tables

Figures

Abbreviations

AMDR	Air and Missile Defense Radar
BMDS	Ballistic Missile Defense System
CH-53K	CH-53K Heavy Lift Replacement Helicopter
CRH	Combat Rescue Helicopter
DAMIR	Defense Acquisition Management Information Retrieval
DOD	Department of Defense
eSRS	Electronic Subcontracting Reporting System
F-15 EPAWSS	F-15 Eagle Passive Active Warning and Survivability System
F-35	F-35 Lightning II Joint Strike Fighter
IFPC Inc 2-I Block 1	Indirect Fire Protection Capability Increment 2—Intercept Block 1
KC-46A	KC-46 Tanker Modernization Program
MDAP	Major Defense Acquisition Program
MRL	manufacturing readiness level
NA	not applicable
NGJ Inc 1	Next Generation Jammer Increment 1
SAR	Selected Acquisition Report
T-AO 205	John Lewis Class Fleet Replenishment Oiler
TBD	to be determined
TRL	technology readiness level
WSARA	Weapon Systems Acquisition Reform Act

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Comptroller General
of the United States

April 25, 2018

Congressional Committees

I am pleased to present our 16th annual assessment of the Department of Defense's (DOD) major weapon system acquisition programs—an area on GAO's high-risk list.[1] This year's report offers observations on the performance of DOD's 2017 portfolio of 86 major programs, which the department expects to cost $1.66 trillion in total.[2] This significant financial investment demands keen oversight and continued implementation of key legislative and policy reforms, as well as knowledge-based acquisition practices developed and recommended by GAO.[3]

This year's assessment offers a mixed message for DOD acquisition. On the one hand, we observed positive cost performance in the programs that DOD has initiated since 2010, when acquisition reforms began to take root—a trend we first highlighted in our 2016 assessment. Yet, like so many programs before them, most of these newer programs have continued to proceed without the requisite knowledge that our prior work has shown underpins good program outcomes.

Our work has found that when programs enter development with insufficient knowledge, negative effects can cascade throughout the acquisition cycle. These knowledge shortfalls, or gaps, often begin with program decisions to accept immature technologies at the start of system development, but then later manifest in other forms as the program approaches production. In this environment, decision makers are

[1]GAO, *High-Risk Series: Progress on Many High-Risk Areas, While Substantial Efforts Needed on Others*, GAO-17-317 (Washington, D.C.: Feb. 15, 2017).

[2]Our assessment of DOD's portfolio does not include the cost of the Ballistic Missile Defense System (BMDS), as the program and its elements lack acquisition program baselines needed to support our assessment of cost and schedule change. For more information on BMDS and its elements, see GAO, *Missile Defense: Some Progress Delivering Capabilities, but Challenges with Testing Transparency and Requirements Development Need to Be Addressed,* GAO-17-381 (Washington, D.C.: May 30, 2017). 10 U.S.C. § 225 requires the Missile Defense Agency (MDA) to establish and maintain an acquisition baseline for certain elements of the BMDS, but these baselines are not the same as the acquisition program baselines developed pursuant to 10 U.S.C. § 2435 and DOD acquisition policies. For example, they do not include service-funded operations and sustainment costs needed to support GAO's assessment of cost and schedule change.

[3]See, e.g., Weapon Systems Acquisition Reform Act of 2009, Pub. L. No. 111-23.

confronted with the choice of increasing program investments, despite lacking visibility on whether the program's cost and schedule estimates are achievable, or truncating the program, and subsequently depriving warfighters of a needed capability. We have made numerous recommendations over the years to address these knowledge gaps in DOD's programs.[4] This year, for the first time, we conducted an exploratory statistical analysis of a small sample of 15 programs in production that begins to validate a linkage between the attainment of knowledge and the real-life cost and schedule outcomes that programs deliver. This analysis showed that programs that attained certain knowledge at key points had lower cost and schedule growth than other programs.

Therefore, it is troubling to observe the knowledge gaps that persist in DOD programs, especially in those initiated after 2010. Many of these later programs are only now on the cusp of entering production, or are in early production. As we first observed in 2017, production is the acquisition phase most closely associated with cost growth. Consequently, DOD's continued willingness to accept knowledge gaps in these newer programs—now over 8 years after the implementation of acquisition reforms—indicates that reforms have not yet taken hold to the extent that Congress intended.

Gene L. Dodaro
Comptroller General of the United States

[4]See the Related GAO Products page at the end of this report for examples of products where we have recommended application of knowledge-based acquisition practices within DOD acquisition programs.

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In response to the joint explanatory statement accompanying the Department of Defense Appropriations Act, 2009, this report provides insight into the department's $1.66 trillion portfolio of major weapon programs.[1] It includes observations on (1) the cost and schedule performance of DOD's 2017 portfolio of 86 major weapon programs, (2) the implementation of key acquisition reform initiatives within 57 current and future programs, and (3) the knowledge that 57 current and future programs attained at key decision points in the acquisition process. This report also includes information related to small business participation, pursuant to a provision in a report to the National Defense Authorization Act for Fiscal Year 2013.[2] Specifically, we determined whether individual subcontracting reports from a program's prime contractor or contractors were accepted within the Electronic Subcontracting Reporting System (eSRS).[3] Results from this analysis can be found in appendix I.

Our observations in this report are based on three sets of programs:

- We assessed 86 major defense acquisition programs (MDAP) in DOD's 2017 portfolio for cost and schedule performance.[4] We obtained cost, schedule, and quantity data from DOD's December

[1]See Explanatory Statement, 154 Cong. Rec. H 9427, 9526 (daily ed., Sept. 24, 2008), to the Department of Defense Appropriations Act, 2009, contained in Division C of the Consolidated Security, Disaster Assistance, and Continuing Appropriations Act, 2009, Pub. L. No. 110-329 (2008).

[2]H.R. Rep. No. 112-479, at 284 (2012). The National Defense Authorization Act for Fiscal Year 2013, Pub. L. No.112-239.

[3]The government uses individual subcontracting reports on eSRS as one method of monitoring small business participation, as the report includes goals for small business subcontracting.

[4]Major defense acquisition programs (MDAP) are those identified by DOD or that have a dollar value for all increments estimated to require eventual total expenditure for research, development, test, and evaluation of more than $480 million, or for procurement of more than $2.79 billion, in fiscal year 2014 constant dollars. DOD maintains a list of programs designated as future major defense acquisition programs. These programs have not formally been designated as MDAPs; however, DOD plans for these programs to enter system development, or bypass development and begin production, at which point DOD will likely designate them as MDAPs. We refer to these programs as future or planned major defense acquisition programs throughout this report.

2016 Selected Acquisition Reports (SAR)—which detail initial cost, schedule, and performance baselines and changes over the past year—and from the Defense Acquisition Management Information Retrieval (DAMIR) system, a DOD repository for program data. We conducted our own assessment of data reliability by comparing the SAR data we entered into our weapon system database and the DAMIR data and determined the data were sufficiently reliable for the purposes of our report.

- We also assessed 45 MDAPs currently between the start of development and the early stages of production. We developed a questionnaire to obtain information on the extent to which these programs are following knowledge-based acquisition practices for technology maturity, design stability, and production readiness. The questionnaire asked programs to provide information about systems engineering, design drawings, manufacturing planning and execution, and the implementation of specific acquisition reforms. In addition, the questionnaire requested that programs provide details on scheduling, critical technology levels, major development and early procurement contract data, and other information. We received questionnaire responses from all 45 current programs from October 2017 through December 2017.
- We also assessed 12 future MDAPs not yet in the portfolio to gain additional insights into knowledge they plan to attain before starting development and their plans for implementing key acquisition reforms. We provided a questionnaire to program offices to collect information on schedule events, costs, and numerous acquisition reforms, and received responses from all 12 future programs from October 2017 through January 2018.

In addition, we present individual assessments of 57 MDAPs, which include the 45 MDAPs currently in development or early production, as well as the 12 future programs. Appendix II provides additional information on our objectives, scope, and methodology.

We conducted this performance audit from May 2017 to April 2018 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.

Background

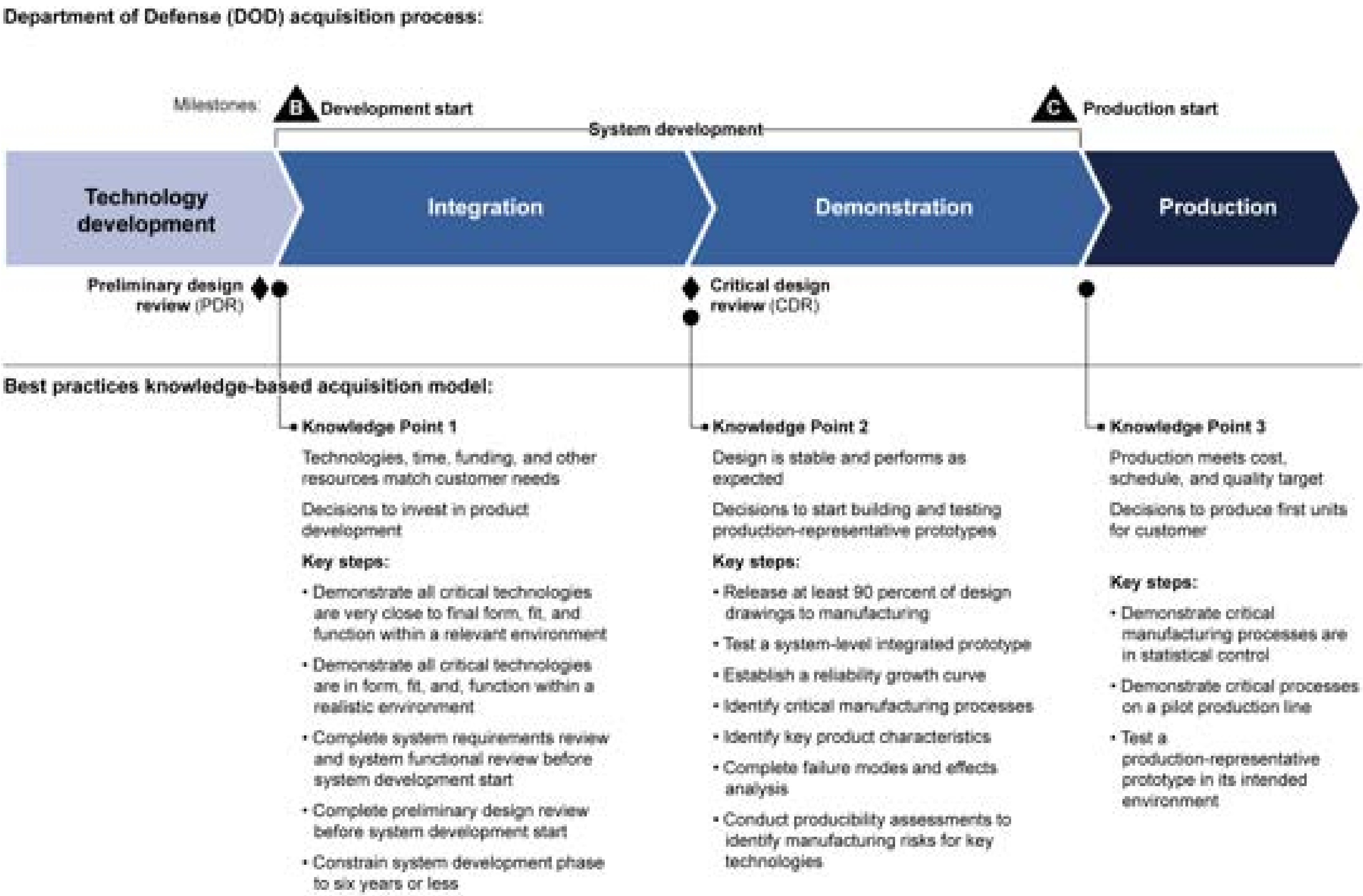
DOD acquires new weapons for its warfighters through a management process known as the Defense Acquisition System.[5] This system generally requires defense acquisition programs to proceed through three phases that are (1) technology maturation and risk reduction, (2) engineering and manufacturing development, and (3) production and deployment. In this report we refer to these three phases more simply as technology development, system development, and production. Programs typically complete a series of milestone reviews and other key decision points that authorize entry into a new acquisition phase.

Our body of work has shown that attaining high levels of knowledge before significant commitments are made during product development drives positive acquisition outcomes.[6] We have found that in order to reduce risk there are three key points where programs should demonstrate critical levels of knowledge before proceeding to the next acquisition phase: development start, system-level critical design review, and production start. Figure 1 aligns the acquisition milestones described in DOD Instruction 5000.02, which establishes policy for the management of acquisition programs, with these three key decision points.

[5]Department of Defense Directive 5000.01, *The Defense Acquisition System* (Nov. 2007); Department of Defense Instruction 5000.02, *Operation of the Defense Acquisition System* (Jan. 2015) [incorporating change 3 (Aug. 2017)] ("DOD Instruction 5000.02").

[6]GAO, *Best Practices: DOD Can Achieve Better Outcomes by Standardizing the Way Manufacturing Risks Are Managed*, GAO-10-439 (Washington, D.C.: Apr. 22, 2010); *Best Practices: High Levels of Knowledge at Key Points Differentiate Commercial Shipbuilding from Navy Shipbuilding*, GAO-09-322 (Washington, D.C.: May 13, 2009); *Defense Acquisitions: A Knowledge-Based Funding Approach Could Improve Major Weapon System Program Outcomes*, GAO-08-619 (Washington, D.C.: July 2, 2008); *Best Practices: Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes*, GAO-02-701 (Washington, D.C.: July 15, 2002); *Best Practices: Better Matching of Needs and Resources Will Lead to Better Weapon System Outcomes*, GAO-01-288 (Washington, D.C.: Mar. 8, 2001); and *Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes*, GAO/NSIAD-99-162 (Washington, D.C.: July 30, 1999).

Figure 1: Defense Acquisition Cycle and GAO-Identified Knowledge Points



Source: GAO analysis of DOD-provided data, DOD Instruction 5000.02, and best practices. | GAO-18-360SP

Knowledge associated with these three points builds over time. Our prior work on knowledge-based approaches shows that a knowledge deficit early in a program can cascade through design and production, leaving decision makers with less knowledge to support decisions about when and how to move into subsequent acquisition phases that require more budgetary resources. Under a knowledge-based approach, demonstrating technology maturity is a prerequisite for moving forward into system development, during which time the focus should be on design and integration. Similarly, a stable and mature design is also a prerequisite for moving into production, where the focus should be on efficient manufacturing. Appendix III provides additional details about key practices at each of the knowledge points.

Our work has led to multiple recommendations that DOD has generally or partially agreed with and made progress in implementing. For example, our previous work recommended DOD ensure programs conduct a preliminary design review prior to starting development, and DOD's policy now reflects this. Further, our work has influenced efforts within DOD and Congress to address some of the challenges in the defense acquisition system—primarily, that it takes longer and costs more to develop and produce the systems required to perform DOD's various missions and operations. Notably, the Weapon Systems Acquisition Reform Act of 2009 (WSARA) sought to improve the way DOD acquires major weapon systems and incorporated many of our related recommendations.[7] WSARA revised the certifications that programs were expected to complete before being approved for system development start. Programs are currently required to make certain determinations and certifications that they have met the following requirements, among others, prior to entering system development:[8]

- The program has conducted appropriate trade-offs among cost, schedule, and performance objectives;
- The program has demonstrated a high likelihood of accomplishing its intended mission based on a preliminary design review and formal post-preliminary design review assessment; and

[7]Pub. L. No. 111-23.

[8]This requirement is codified as amended at 10 U.S.C. § 2366b. Since WSARA was implemented in late 2009, Congress has revised or repealed some of its original requirements. For example, the National Defense Authorization Act for Fiscal Year 2016 repealed the requirement for programs to conduct competitive prototyping prior to starting system development. Pub. L. No. 114-92, § 822(b). Now, program acquisition strategies generally are to include the use of competitive prototypes before the start of system development to the maximum extent practicable and consistent with the economical use of available financial resources. 10 U.S.C. § 2431b(c).

- The Under Secretary of Defense for Research and Engineering has independently verified that critical technologies are mature and demonstrated in a relevant environment.[9]

In 2010, DOD started its own acquisition reform initiatives, as outlined in its “Better Buying Power” memorandums.[10] These reforms included the requirement that programs conduct affordability and “should-cost” analyses to encourage program managers to find cost savings.[11]

Our work has shown that DOD, through its Instruction 5000.02, has incorporated WSARA and other initiatives to address sound management practices, such as realistic cost estimates, use of prototypes, and systems engineering.

[9]Demonstration in a relevant environment is Technology Readiness Level (TRL) 6. Demonstration in an operational environment is TRL 7 and this is the level of maturity GAO’s knowledge-based acquisition practices work has determined constitutes a low risk for starting a product development program. See appendix VI for detailed descriptions of TRLs. In addition, a major defense acquisition program generally may not receive approval for development start until the milestone decision authority certifies that the technology in the program has been demonstrated in a relevant environment. 10 U.S.C. § 2366b(a)(2). Under certain circumstances this requirement may be waived. *Id.* § 2366b(d).

[10]DOD’s Better Buying Power memorandums are an initiative to strengthen DOD’s purchasing practices, improve industry productivity, and provide an affordable military capability to the warfighter. According to DOD, it encompasses a set of fundamental acquisition principles to achieve greater efficiencies through affordability, cost control, elimination of unproductive processes and bureaucracy, and promotion of competition.

[11]Affordability analyses promote responsible and sustainable investment decisions by examining the implications of today’s capability requirements choices and investment decisions based on reasonable projections of future needs before substantial resources are committed. “Should-cost” analyses inform the management of all costs throughout the acquisition life cycle, as well as negotiations with industry over contract costs and incentives. “Should-cost” analyses are also focused on eliminating non-value-added overhead and unnecessary reporting requirements.

Ten Observations on the Cost and Schedule Performance of DOD's 2017 Major Defense Acquisition Program Portfolio

Our analysis of DOD's 2017 MDAP portfolio shows that programs initiated since 2010 performed better than the remainder of the portfolio and realized a cost decrease of $5.6 billion between 2016 and 2017. However, these savings were not big enough to avert an overall cost increase of $54.7 billion across the entire portfolio last year, the majority of which was due to quantity increases. It is too early to say whether these savings could curb that level of growth in future years. We will likely gain visibility into that prospect as more programs that began after 2010 enter production.

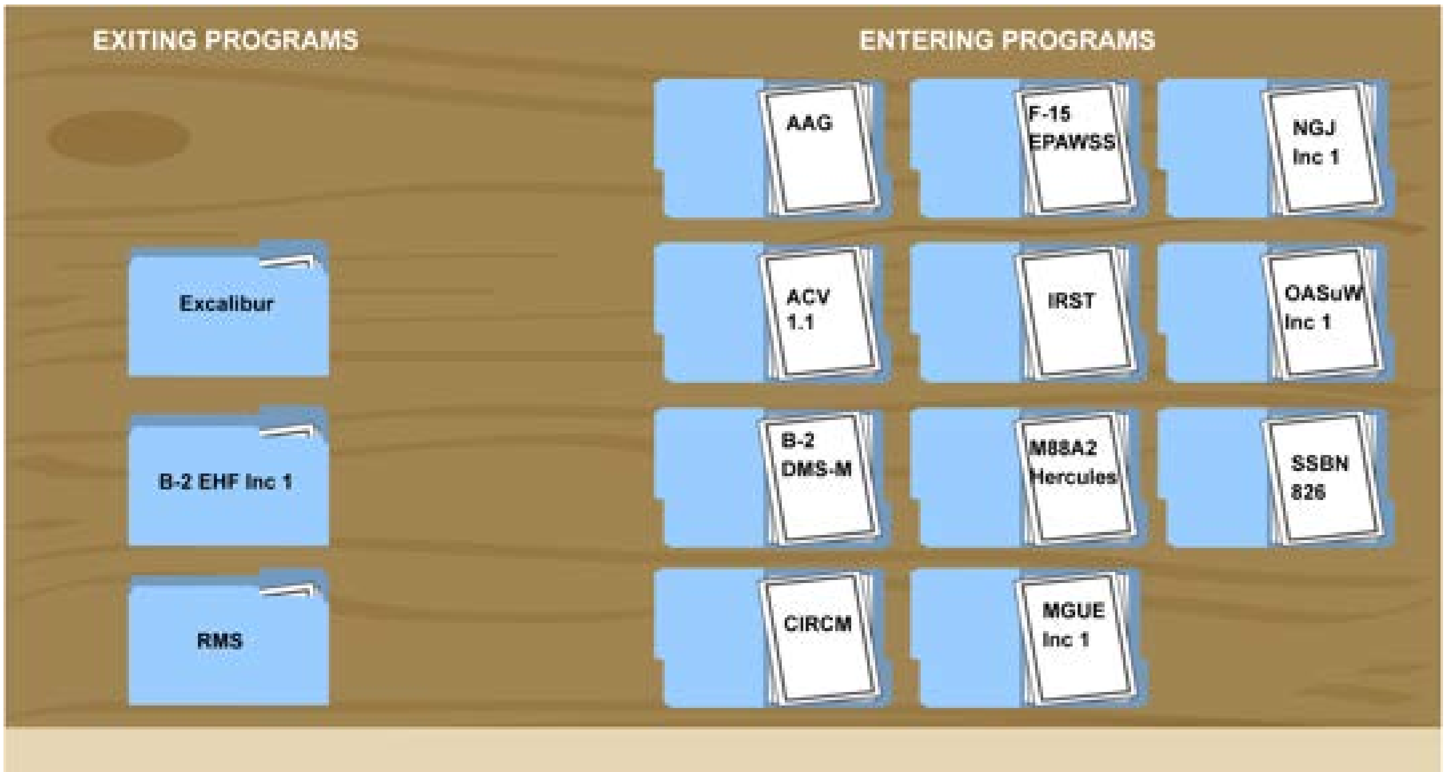
DOD's 2017 Portfolio Has Grown in Number of Programs and Cost

1. **The 2017 portfolio consists of 86 programs, which will cost over $1.66 trillion to acquire.**[12]

   Three programs exited the portfolio in 2017, after they completed their planned procurements or were cancelled, and 11 new programs were added, which resulted in the largest number of programs within the portfolio since 2011. Figure 2 shows the programs exiting and entering between 2016 and 2017.

[12] All dollar figures are in fiscal year 2018 constant dollars, unless otherwise noted.

Figure 2: DOD's Major Defense Acquisition Program Portfolio's Gains and Losses between 2016 and 2017



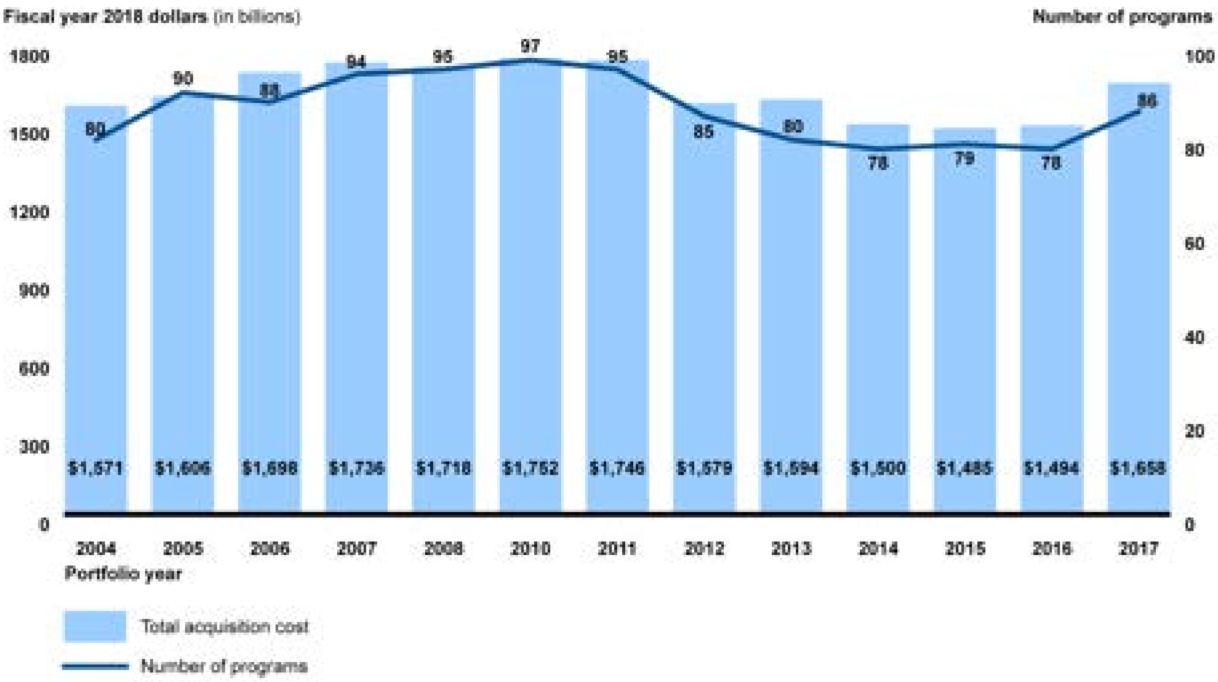
AAG	Advanced Arresting Gear
ACV 1.1	Amphibious Combat Vehicle Phase 1 Increment 1
B-2 DMS-M	B-2 Defensive Management System-Modernization
B-2 EHF Inc 1	B-2 Extremely High Frequency SATCOM and Computer Increment 1
CIRCM	Common Infrared Countermeasure
Excalibur	Excalibur Precision 155mm Projectiles
F-15 EPAWSS	F-15 Eagle Passive Active Warning Survivability System
IRST	Infrared Search and Track
M88A2 Hercules	M88A2 Heavy Equipment Recovery Combat Utility Lift Evacuation System
MGUE Inc 1	Military Global Positioning System User Equipment Increment 1
NGJ Inc 1	Next Generation Jammer Increment 1
RMS	Remote Minehunting System
OASuW Inc 1	Offensive Anti-Surface Warfare Increment 1
SSBN 826	Columbia Class Submarine

Source: GAO analysis of Department of Defense data. | GAO-18-360SP

- DOD's net gain of eight programs was a contributing factor in the 2017 portfolio's total cost change of $164 billion and marks the second year of increases after 4 years of decreasing annual costs with one small increase between 2010 and 2017.

Figure 3 shows the number of programs and total cost of this year's portfolio compared to previous years.

Figure 3: DOD's Portfolio Cost and Size Have Increased Since 2016, but Remain within Historic Ranges



Source: GAO analysis of Department of Defense data. | GAO-18-360SP

Note: DOD did not issue Selected Acquisition Reports (SAR) in 2009, which precludes us from having the cost baseline information necessary to include 2009 in this analysis.

- For other analyses, detailed below, we added the first full estimates for the 11 programs that entered the 2017 portfolio to the 2016 portfolio. We also subtracted the funding associated with the three programs that exited the portfolio from 2016 to 2017. We took these steps in order to make the two portfolios comparable before measuring cost and schedule differences.
- Under this approach, over the past year, DOD's cost estimates for these programs have increased by $54.7 billion, or 3.4 percent, of which approximately $47.7 billion is attributed to quantity increases.

- This leaves $7 billion in cost increases that were likely caused by an increase in the time and effort required to complete development and procurement of several programs.
- In comparison to last year, the 2017 portfolio's development costs increased by $8.8 billion and procurement costs increased $45.4 billion.[13]

Three programs—the Navy's MQ-4C Triton Unmanned Aircraft System and P-8A Poseidon Multi-Mission Maritime Aircraft and the Air Force's Next Generation Operational Control System—account for $3.5 billion, or nearly 40 percent, of the aggregate development cost increase. One program, the Navy's SSN 774 Virginia Class Submarine, accounts for $38 billion, or nearly 84 percent, of the aggregate procurement cost growth due to an increase in procurement quantity.

Source: GAO analysis of Department of Defense (DOD) data. | GAO-18-360SP

- In addition, the 2017 portfolio's average time to deliver capability increased by just over a month in the past year—an improvement over the delays incurred in the previous two portfolios we reviewed.

Table 1 details changes in funding and average cycle times to deliver initial capabilities for the current portfolio.

Table 1: DOD Estimates that its 2017 Portfolio Will Cost More and Take Longer to Deliver as Compared to the 2016 Portfolio

Fiscal year 2018 dollars in billions

	2016 portfolio estimates[a]	2017 portfolio estimates	Net change between 2016 and 2017	Percentage change between 2016 and 2017
Total estimated research and development cost	305.2	313.9	8.8	2.9
Total estimated procurement cost	1,284.6	1,330.0	45.4	3.5
Total estimated acquisition cost[b]	1,603.1	1,657.8	54.7	3.4
Average cycle time (in months) to deliver initial capabilities	121.7	123.0	1.3	1.1

Source: GAO analysis of Department of Defense (DOD) data. | GAO-18-360SP

[a]For the 2016 portfolio, we included $132.3 billion in first full estimates for the 11 programs that entered the 2017 portfolio and subtracted $23.2 billion for the three programs that exited the portfolio between 2016 and 2017. These adjustments made the portfolios comparable for measurement of cost and schedule differences.

[b]In addition to research and development and procurement costs, total acquisition cost includes acquisition-related operation and maintenance and system-specific military construction costs.

[13]In addition, the 2017 portfolio includes a total of $500 million in military construction and acquisition operations and maintenance costs.

Appendix IV outlines the cost performance of individual programs over the past year, 5 years, and since first full estimate. Appendix V provides portfolio-level information on cost and schedule changes over the past 5 years and since programs' first full estimates.

- Forty-three programs, or half the 2017 portfolio, incurred cost growth that totaled $74.8 billion ($47.7 billion of which was due to quantity increases), while the other 43 programs experienced cost decreases that totaled $20.1 billion.
- Most programs' cost changes were between 0 and 5 percent, whether they were decreases or increases.

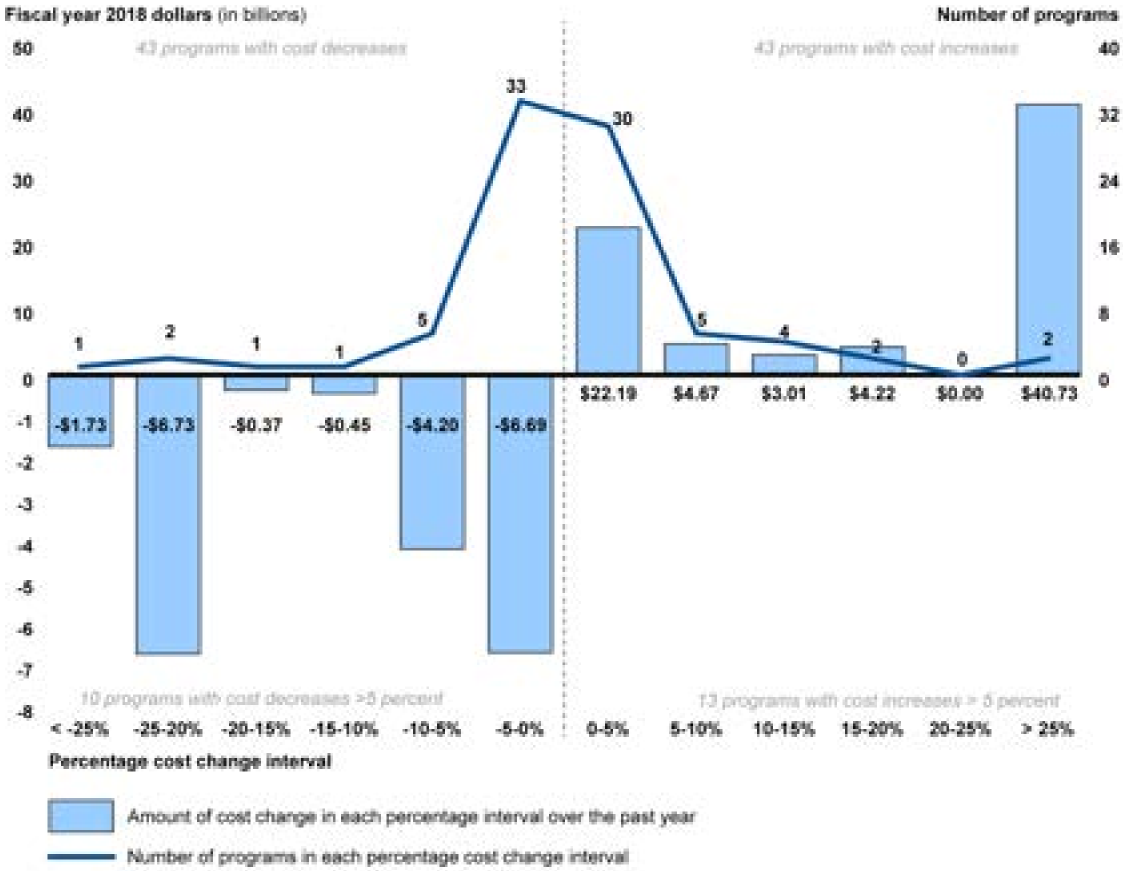
We identified three programs with cost changes greater than 25 percent, two of which were mainly driven by quantity changes:

- the Navy's SSN 774 Virginia Class Submarine, which incurred 40.6 percent cost growth attributable to a quantity increase;
- the Air Force's Next Generation Operational Control System, which experienced 25.4 percent cost growth without a quantity increase; and
- the Air Force's F-15 Eagle Passive Active Warning Survivability System, which reduced its planned cost by 39.3 percent following a quantity decrease.

Source: GAO analysis of Department of Defense (DOD) data. | GAO-18-360SP

Figure 4 displays the portfolio's total acquisition cost change from 2016 to 2017 for each program distributed among percentage change intervals irrespective of changes to quantity.

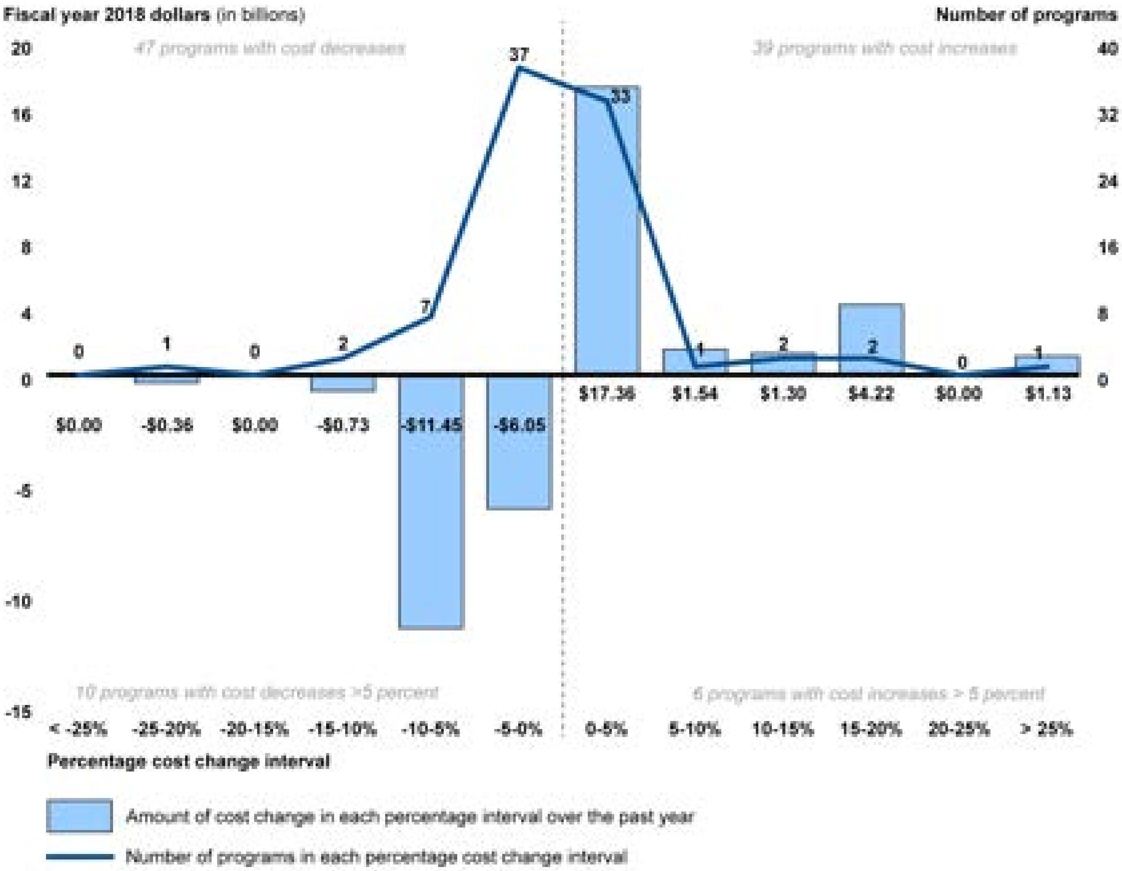
Figure 4: Between 2016 and 2017, 23 DOD Programs Experienced Total Acquisition Cost Increases or Decreases of Greater than 5 Percent



Source: GAO analysis of Department of Defense data. | GAO-18-360SP

Figure 5 shows the portfolio's total acquisition cost change not due to quantity changes from 2016 to 2017 for each program distributed among percentage change intervals.

Figure 5: When Controlling for Quantity Changes, 16 DOD Programs Experienced Total Acquisition Cost Increases or Decreases of Greater than 5 Percent between 2016 and 2017



Source: GAO analysis of Department of Defense data. | GAO-18-360SP

Programs in DOD's 2017 Portfolio Gained More Buying Power

2. **Since last year's assessment, programs in DOD's 2017 portfolio realized a combined $2.3 billion gain in buying power—meaning DOD is able to buy more goods or services for the same level of funding. Nonetheless, this gain was significantly less than the $10.7 billion increase in buying power achieved by the 2016 portfolio.**

   Buying power is the amount of goods or services that can be purchased given a specified level of funding. To determine changes in buying power, the effects of quantity changes must be isolated from other factors that affect cost.

- A program's cost can increase because of additional quantities. While that does represent a cost increase, it does not necessarily indicate acquisition problems or a loss of buying power. Alternatively, a program's cost can decrease due to a reduction in quantity and may still experience a buying power gain or loss.

Table 2 details the buying power changes reflected in the 2017 portfolio. Negative numbers indicate decreased costs and a gain in buying power. Positive numbers indicate the opposite.

Table 2: Programs that Comprise DOD's 2017 Portfolio Gained $2.3 Billion in Buying Power since 2016

Fiscal year 2018 dollars in millions

	Number of programs	Actual procurement cost change since 2016	GAO calculated cost change attributable to quantity changes	GAO calculated cost change not attributable to quantity changes
Increased buying power	**51**	**25,243.10**	**45,497.35**	**-20,254.25**
Procurement cost decreased with no quantity change	31	-6,295.70	0.00	-6,295.70
Quantity increased with less cost increase than anticipated	14	39,933.88	52,531.44	-12,597.56
Quantity decreased with more cost decrease than anticipated	6	-8,395.08	-7,034.09	-1,360.99
Decreased buying power	**29**	**20,182.98**	**2,191.24**	**17,991.74**
Procurement cost increased with no quantity change	21	5,716.15	0.00	5,716.15
Quantity increased with more cost increase than anticipated	5	14,428.03	3,386.03	11,042.00
Quantity decreased with less cost decrease than anticipated	3	38.80	-1,194.79	1,233.59
No change in buying power	**6**	**0.00**	**0.00**	**0.00**
Portfolio totals	**86**	**45,426.08**	**47,688.59**	**-2,262.51**

Source: GAO analysis of Department of Defense (DOD) data. | GAO-18-360SP

Note: We calculated buying power by comparing the actual procurement cost changes against our calculated cost changes attributable to quantity increases or decreases. To do this, we multiplied the quantity change by the program's acquisition procurement unit cost.

Future Funding Requirements Have Increased

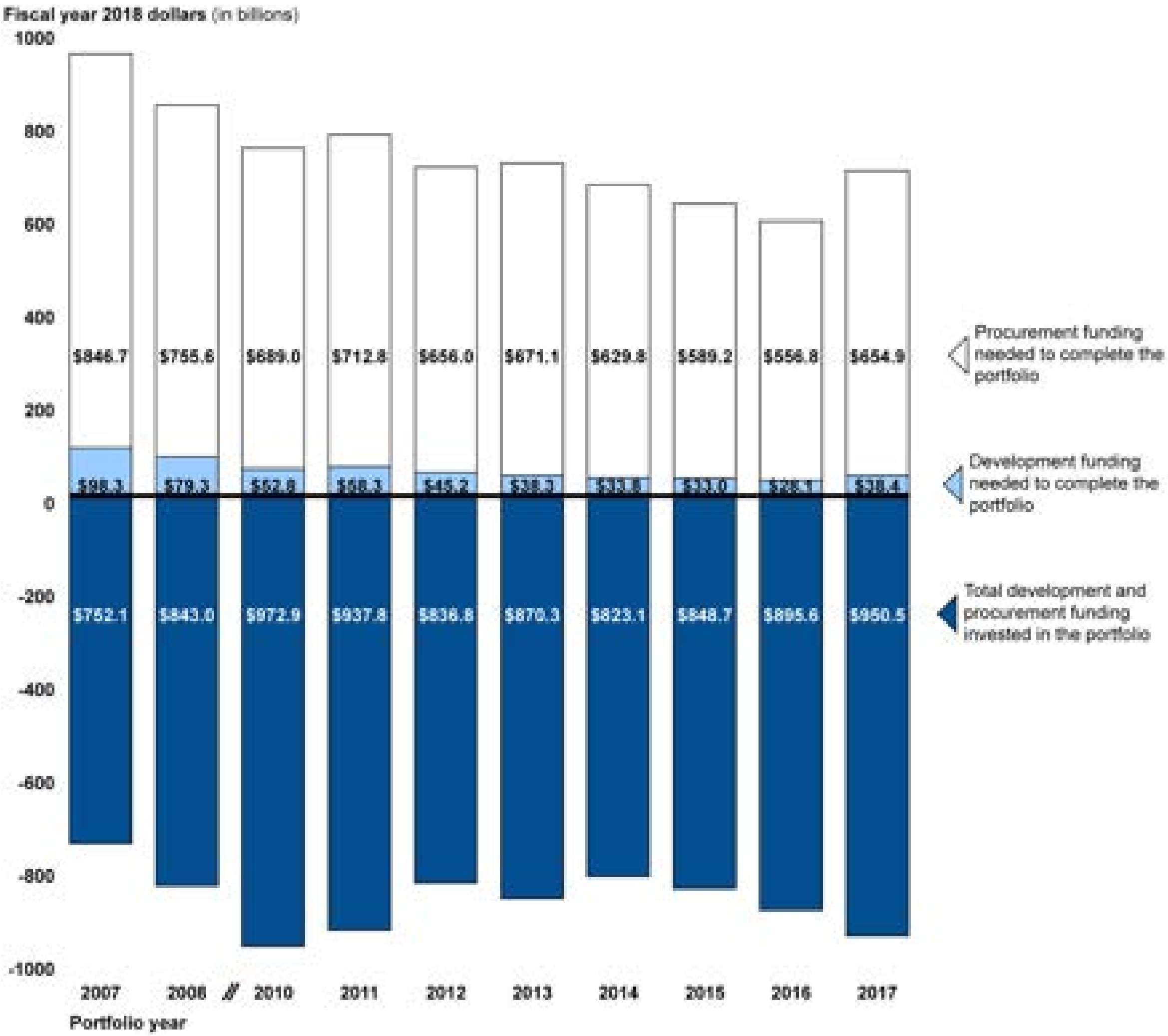
3. The amount of future funding needed to complete the 2017 portfolio's planned development and procurement activities totals $693.3 billion—almost $108 billion more than last year's portfolio.

While this year's increase in future funding requirements can be explained, in part, by the 11 programs added to the portfolio, it also signifies a reversal of the trend we have reported for the past 3 years of decreases in future funding required for both development and procurement.

- Future funding details the amount of investment required beyond the current fiscal year for all programs to complete their development and procure all planned quantities.
- Of the 2017 portfolio's future funding requirements, $38.4 billion is slated for development and $654.9 billion for procurement.
- The $38.4 billion required for future development is an increase of $10.3 billion over last year's assessment and, beyond just an increase in new programs, could be an indicator that current programs have added additional requirements that carry greater risk, are taking more complex acquisition approaches, or are relying on less mature technologies. Nevertheless, the 2017 portfolio's future funding need, for both development and procurement, is $251.7 billion less than the amount that the 2007 portfolio was estimated to have required a decade ago.
- Notably, the 2007 portfolio had fewer sunk costs than it had future funding needs. That ratio has reversed for the current portfolio. Sunk costs in the 2017 portfolio are around the same amount now as they were in 2011, shortly after acquisition reforms were implemented.
- Further, the amount of future development funding needed in the current portfolio is 60 percent less than the amount the 2007 portfolio required ($38.4 billion compared to $98.3 billion). This decrease indicates that, on average, programs in the current portfolio might be further along in the acquisition process than programs in the 2007 portfolio were at the same juncture.

Figure 6 further compares the cost differences between the current and previous years' portfolios each year from 2007 to 2017.

Figure 6: DOD's 2017 Portfolio Shows Changes in Funding Requirements and Sunk Costs that Indicate Programs Are Further Along in the Acquisition Process



Source: GAO analysis of Department of Defense data. | GAO-18-360SP

Note: DOD did not issue SARs in 2009, which precludes us from having the cost baseline information necessary to include 2009 in this analysis.

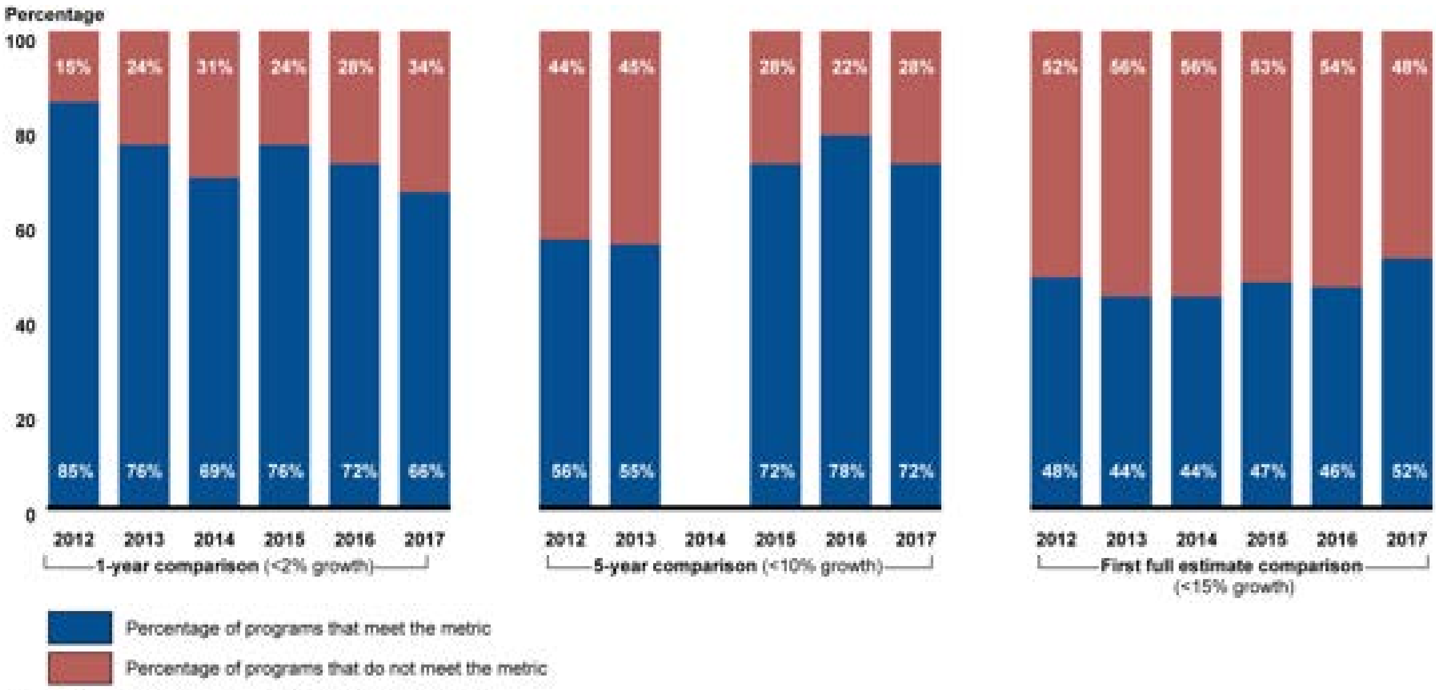
4. Fewer DOD programs meet 1-year and 5-year cost growth metrics, but over half of the current programs show less than 15 percent cost growth since initial estimates.

In December 2008, GAO, DOD, and the Office of Management and Budget agreed on a set of metrics, which we have been reporting on since 2011, to measure DOD program cost growth over time. Although DOD no longer supports the use of these metrics, we continue to believe the current metrics have value.

- The metrics measure cost performance over three defined periods: the preceding year, the preceding 5 years, and since first full estimates were established. If programs exceed these metrics, they are experiencing higher than normal cost growth and if a high percentage of programs exceed these metrics, it is an indication of excessive portfolio cost growth. For DOD's 2017 portfolio, we observed:
  - Less than 2 percent cost growth over the past year: 66 percent of programs met this metric, down from 72 percent in last year's portfolio. This continues a general trend downward since 2012.
  - Less than 10 percent cost growth over the past 5 years: 72 percent of programs met this metric, down from 78 percent in last year's portfolio. This represents a significant improvement over 2012.
  - Less than 15 percent cost growth since first full estimate: 52 percent of programs met this metric, which is an improvement over all previous portfolios dating back to 2012.
- These results indicate that short-term cost growth is increasing in some programs, while longer-term cost growth is slowing.

Figure 7 illustrates the 2017 portfolio's performance against the three aforementioned metrics and how that performance compares to other portfolios since 2012.

Figure 7: DOD's 2017 Portfolio Reflects a Decline in Performance against 1- and 5-Year Cost Growth Metrics, but Demonstrates Improvement in Meeting the Metric for Cost Growth since First Full Estimate



Source: GAO analysis of Department of Defense data. | GAO-18-360SP

Note: DOD did not issue Selected Acquisition Reports in 2009, which precluded us from having the cost baseline information necessary to assess the 5-year performance of the 2014 portfolio.

Appendix IV provides additional detail on historic cost performance in individual programs, which informed this analysis.

5. **The 2017 portfolio has experienced about $537 billion in cost growth from original estimates. However, $464 billion of this growth occurred 5 or more years ago. The 2017 portfolio realized 51 percent of its cost growth, or $272 billion, after programs started production.**

   Approximately 86 percent of the total acquisition cost growth reflected in DOD's 2017 portfolio occurred prior to 2012.

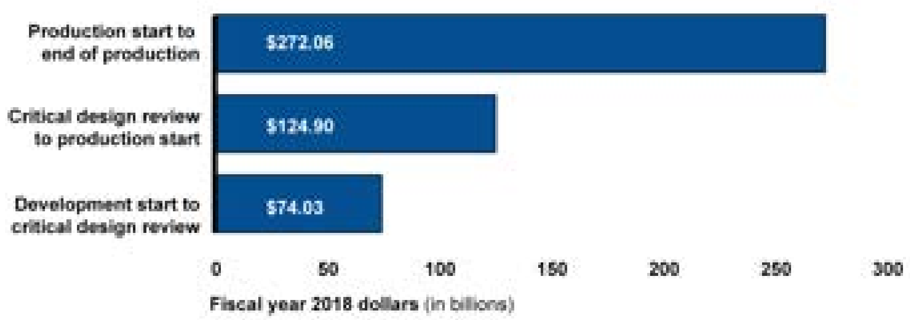
- We observed that costs for the 2017 portfolio have grown throughout the program acquisition cycle, and a majority of this cost growth occurred after programs began production.
- Our prior work has shown that cost increases incurred during production may indicate programs entered production prior to

attaining key knowledge related to technology maturity, design stability, or production readiness. In other cases, production cost growth can be attributed to decisions to increase quantities or improve capabilities, often years after DOD has developed and approved a first full estimate for the program.

- Our analysis found that 62 of 86 programs in DOD's 2017 portfolio are in production.

Figure 8 shows the 2017 portfolio's cost growth throughout the various acquisition phases.

Figure 8: Programs in DOD's 2017 Portfolio Incurred Most of Their Cost Growth after Production Start



Source: GAO analysis of Department of Defense data. | GAO-18-360SP

Notes: To accommodate shipbuilding programs in this analysis, we correlated detail design contract awards, fabrication starts, and lead ship deliveries with development start, critical design review, and production start, respectively. Approximately $66 billion in cost growth occurred in programs either prior to starting system development or prior to the program being designated as a major defense acquisition program, or was included in older Selected Acquisition Reports we do not have, all of which prevented us from allocating that total in our analysis.

Programs Initiated since 2010 Currently Demonstrate Better Cost Performance than Older Programs

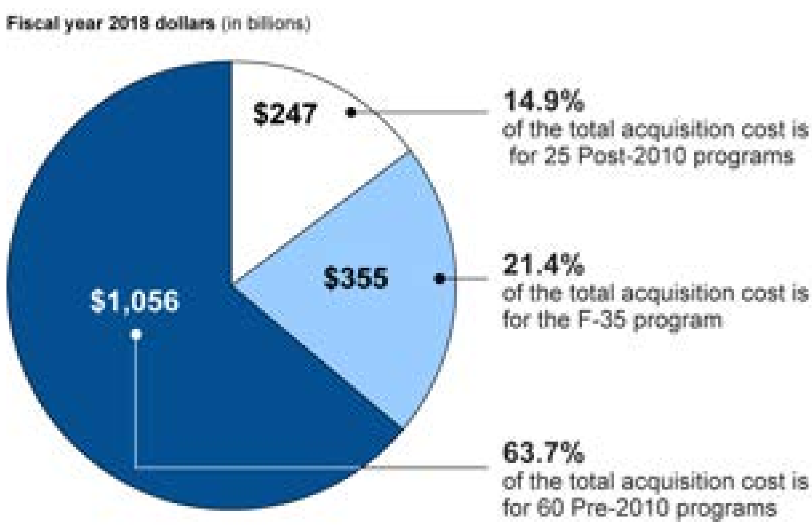
6. **DOD has initiated 25 programs since 2010, when the government implemented significant acquisition reforms. These 25 programs represent 29 percent of the 86 programs in the current portfolio, but only account for about 15 percent of the portfolio's total acquisition cost.**

   The current portfolio can be divided into two sub-portfolios—25 programs that DOD initiated since 2010 and 61 programs initiated prior to 2010. The 25 programs initiated since 2010 have followed updated procedures that incorporated WSARA reforms and "Better Buying Power" initiatives.

- The lower total acquisition cost in the post-2010 sub-portfolio may be due, in part, to the acquisition strategies that these programs have adopted. For instance, acquisition strategies that employ lower-risk, less complex approaches to system development—such as new increments of existing capabilities or affordability-based capability trades—can produce better cost outcomes.

Figure 9 illustrates how the current portfolio's total acquisition cost is apportioned between programs that began before and since 2010 and as compared to DOD's largest acquisition program, the $355 billion F-35 Lightning II Joint Strike Fighter, which entered development in 2001.

Figure 9: Over 85 Percent of the 2017 Portfolio's Estimated Total Acquisition Cost Is for 61 Programs That DOD Initiated Prior to 2010



Source: GAO analysis of Department of Defense data. | GAO-18-360SP

7. **Our analysis of the 2017 portfolio showed differences in cost performance between programs that began before and since 2010. We found that the acquisition reforms that DOD began to implement that year were a driving factor behind the cost changes.**

   Between December 2015 and December 2016:

- the sub-portfolio of programs initiated since 2010, overall, decreased their estimated total acquisition costs by $5.6 billion.

- the sub-portfolio of programs initiated before 2010 incurred an estimated aggregate total acquisition cost increase of $60.3 billion.
- At the same time, the average time to deliver capability increased by just under 1 month for the sub-portfolio of programs initiated before 2010, but increased by 2.6 months for the sub-portfolio of programs initiated since 2010. This difference could be attributed to older programs being much further along in production and having schedules less prone to change.

Table 3 details the changes in estimated funding needs and average cycle time to deliver initial capabilities for the sub-portfolio of programs initiated since 2010.

Table 3: DOD Estimates That Its 2017 Sub-portfolio of Programs Initiated since 2010 Will Cost Less, but Take Longer to Deliver, as Compared to 2016

Fiscal year 2018 dollars in billions

	2016 sub-portfolio estimates[a]	2017 sub-portfolio estimates	Net change between 2016 and 2017	Percentage change between 2016 and 2017
Total estimated research and development cost	53.2	54.1	0.9	1.7
Total estimated procurement cost	195.8	189.4	-6.3	-3.2
Total estimated acquisition cost[b]	252.4	246.8	-5.6	-2.2
Average cycle time (in months) to deliver initial capabilities	92.4	95	2.6	2.8

Source: GAO analysis of Department of Defense (DOD) data. | GAO-18-360SP

[a]For the 2016 sub-portfolio, we included $126.9 billion in first full estimates for the 9 programs initiated since 2010 that entered the 2017 sub-portfolio. This adjustment made the sub-portfolios comparable for measurement of cost and schedule differences.

[b]In addition to research and development and procurement costs, total acquisition cost includes costs for acquisition-related operations and maintenance and system-specific military construction.

Table 4 details the changes in estimated funding needs and average cycle time to deliver initial capabilities for the sub-portfolio of programs initiated before 2010.

Table 4: DOD Estimates That Its 2017 Sub-portfolio of Programs Initiated before 2010 Will Cost More and Take Slightly Longer to Deliver, as Compared to 2016

Fiscal year 2018 dollars in billions

	2016 sub-portfolio estimates[a]	2017 sub-portfolio estimates	Net change between 2016 and 2017	Percentage change between 2016 and 2017
Total estimated research and development cost	252.0	259.8	7.9	3.1
Total estimated procurement cost	1,088.8	1,140.6	51.8	4.8

Fiscal year 2018 dollars in billions	2016 sub-portfolio estimates[a]	2017 sub-portfolio estimates	Net change between 2016 and 2017	Percentage change between 2016 and 2017
Total estimated acquisition cost[b]	1,350.7	1,411.0	60.3	4.5
Average cycle time (in months) to deliver initial capabilities	133.9	134.8	0.9	0.7

Source: GAO analysis of Department of Defense (DOD) data. | GAO-18-360SP

[a]For the 2016 sub-portfolio, we included $5.4 billion in first full estimates for the 2 programs initiated before 2010 that entered the 2017 sub-portfolio and subtracted $23.2 billion for the three programs that exited the sub-portfolio between 2016 to 2017. These adjustments made the sub-portfolios comparable for measurement of cost and schedule differences

[b]In addition to research and development and procurement costs, total acquisition cost includes costs for acquisition-related operations and maintenance and system-specific military construction.

In fiscal year 2017, we compared the cost growth of weapon systems development programs for a 5-year period after WSARA's implementation to the 10-year period prior to the act—estimating about a 75 percent, or $36.0 billion, reduction in the rate of development cost growth. While it is not certain that the act's implementation was the sole reason for this reduction in cost growth, we found that it was the driving factor.[14]

8. **Between 2016 and 2017, a similar percentage of DOD programs initiated before and since 2010 experienced cost changes of 5 percent or less. However, these 1-year cost changes are, on average, smaller in the programs initiated since 2010.**

   A few programs in each of the two sub-portfolios (prior to 2010 and since 2010) drive a majority of the overall cost changes within the 2017 portfolio.

These programs include:

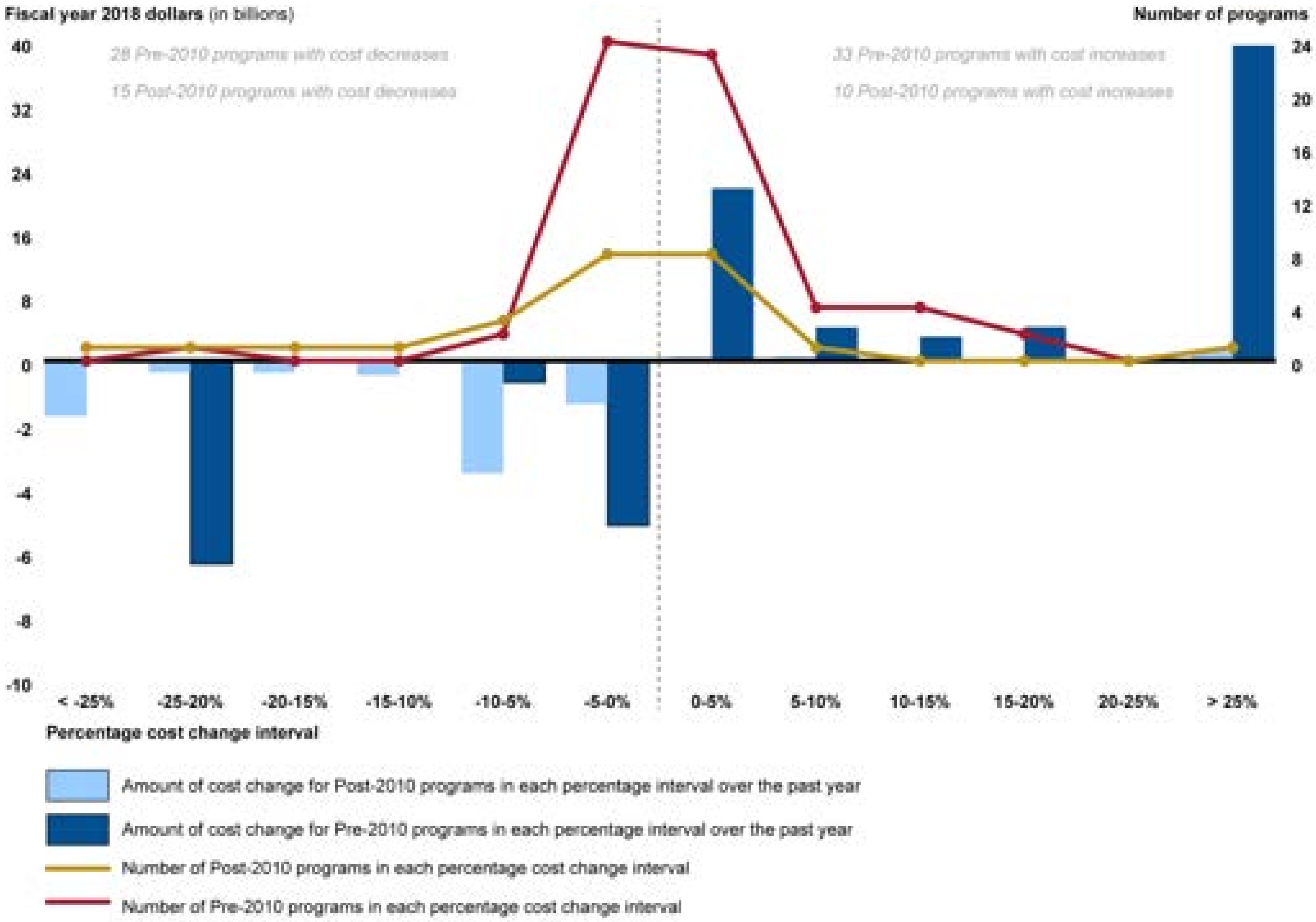
- Programs since 2010: the Air Force's Next Generation Operational Control System, F-15 Eagle Passive Active Warning Survivability System, and KC-46A Tanker Modernization Program.
- Pre-2010 programs: the Navy's Littoral Combat Ship and SSN 774 Virginia Class Submarine and the DOD-wide F-35 Lightning II Joint Strike Fighter program.

Source: GAO analysis of Department of Defense (DOD) data. | GAO-18-360SP

Figure 10 details the distribution of total acquisition cost changes in each percentage interval over the past year within the two sub-portfolios.

[14]GAO, *Performance and Accountability Report: Fiscal Year 2017*, GAO-18-2SP (Washington, D.C.: Nov. 15, 2017).

Figure 10: Programs Initiated since 2010 Show Fewer Significant Year-to-Year Cost Changes as Compared to the Programs Initiated Prior to 2010

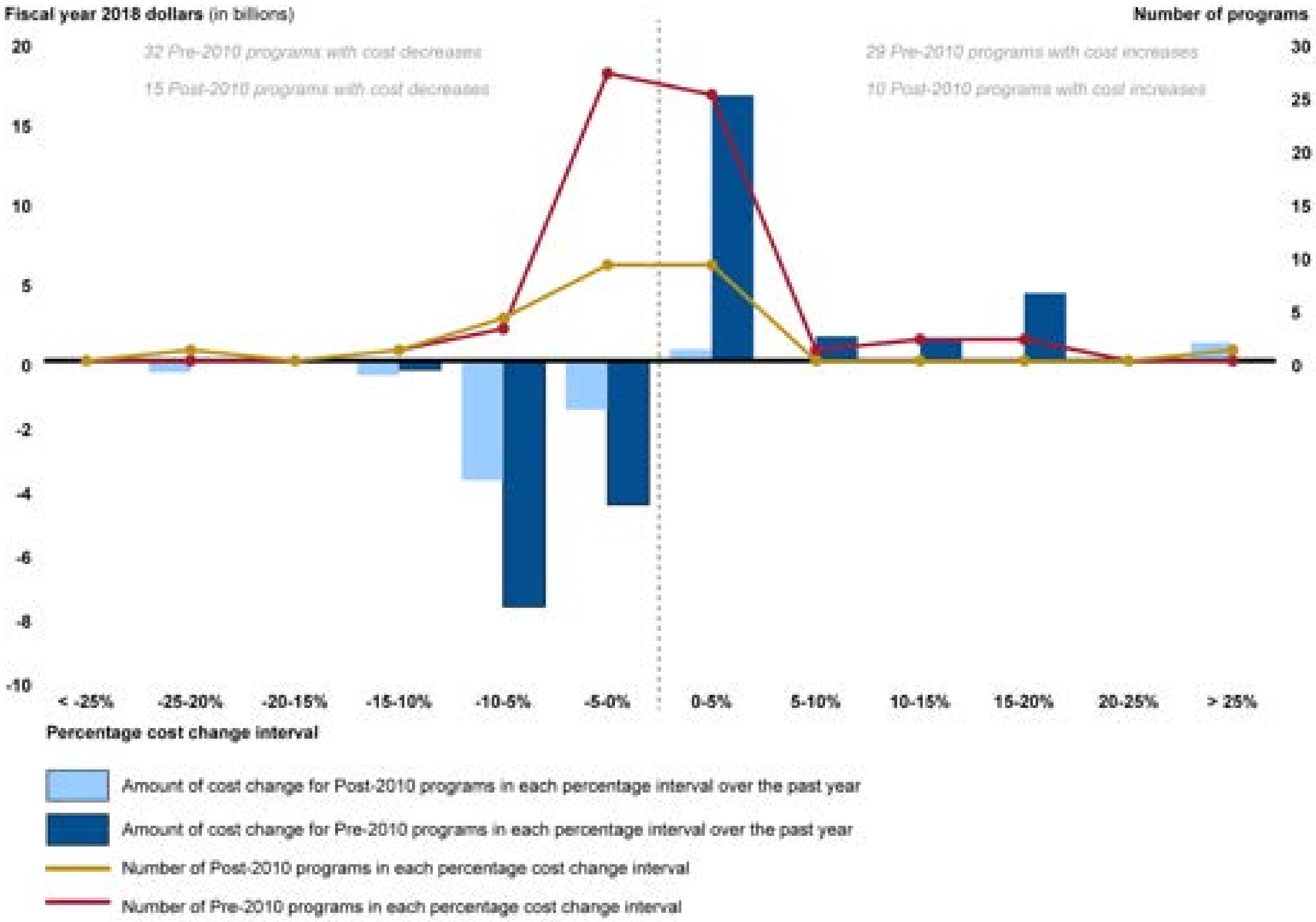


Source: GAO analysis of Department of Defense data. | GAO-18-360SP

- When controlling for quantity changes, the programs initiated since 2010 experienced a cost decrease of $4.2 billion while the older programs incurred an $11.2 billion cost increase. This again indicates that, over a shorter period of time, the programs initiated since 2010 have managed cost growth more effectively than the older programs.

Figure 11 also details the distribution of the total acquisition cost changes over the past year within the two sub-portfolios, but controls for quantity changes.

Figure 11: When Controlling for Quantity Changes, the Programs Initiated since 2010 Incurred an Overall Cost Decrease while Programs Initiated Prior to 2010 Experienced an Overall Cost Increase



Source: GAO analysis of Department of Defense data. | GAO-18-360SP

Programs Initiated since 2010 Gained Buying Power and Experienced Overall Cost Decreases

9. Programs initiated since 2010 gained buying power, while earlier programs incurred an overall loss in buying power.

The 2017 portfolio's overall buying power gain of $2.3 billion was driven by the sub-portfolio of 25 programs initiated since 2010, which together realized a buying power increase of almost $5 billion. On the other hand, the sub-portfolio of 61 programs initiated prior to 2010 produced a buying power decrease of $2.7 billion.

- The disparity in buying power performance between the two sub-portfolios could indicate that acquisition reforms may be yielding dividends in the form of cost efficiencies in newer programs.

Table 5 details the buying power changes reflected in the aforementioned sub-portfolios. Negative numbers indicate decreased costs and a gain in buying power. Positive numbers indicate the opposite.

Table 5: DOD Programs Initiated since 2010 Gained Nearly $5.0 Billion in Buying Power, Which Was Offset by $2.7 Billion in Buying Power Decreases among Programs Initiated before 2010

Fiscal year 2018 dollars in millions

Programs initiated since 2010	Number of programs	Actual procurement cost change since 2016	GAO calculated cost change attributable to quantity changes	GAO calculated cost change not attributable to quantity changes
Increased buying power	15	-6,808.08	-1,454.67	-5,353.41
Decreased buying power	8	464.93	$70.58	394.36
No change in buying power	2	0.00	0.00	0.00
Sub-portfolio totals	**25**	**-6,343.15**	**-1,384.10**	**-4,959.05**
Programs initiated before 2010				
Increased buying power	36	32,051.18	46,952.02	-14,900.84
Decreased buying power	21	19,718.05	2,120.66	17,597.39
No change in buying power	4	0.00	0.00	0.00
Sub-portfolio totals	**61**	**51,769.23**	**49,072.69**	**2,696.54**

Source: GAO analysis of Department of Defense (DOD) data. | GAO-18-360SP

10. Current cost estimates for programs initiated since 2010 have decreased from their original estimates. These programs experienced cost decreases after both critical design review and production start.

DOD's current sub-portfolio of programs initiated since 2010 has achieved cost and schedule outcomes that, when measured cumulatively against the programs' original estimates, have outperformed other DOD programs.

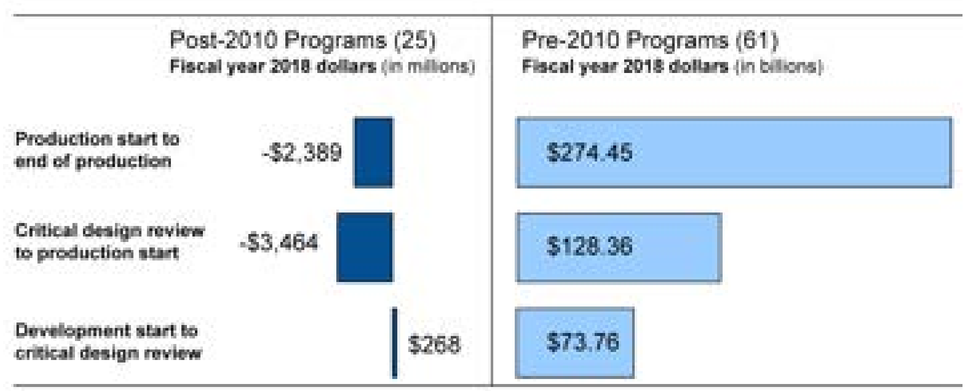
- These 25 programs have achieved a 2.1 percent, or $5.3 billion, cost decrease and, on average, a 9-month delay in delivering capabilities, as compared to their original estimates.
- In comparison, DOD's other 61 programs, which were all initiated before 2010, have experienced cost growth of 62.4 percent, or $542.1 billion, and schedule delays totaling 35 months on average since those programs developed their original estimates.

- Forty percent of the programs initiated since 2010 (10 out of 25) are in production while 85 percent (52 out of 61) initiated before 2010 are in production.
- Cumulative cost growth experienced by the programs initiated before 2010 occurred during all phases of the acquisition process, although most occurred after the start of production.

Conversely, we observed that programs initiated since 2010 have, over a shorter period of time, reduced their planned costs after critical design review and the start of production with a small amount of cost growth ($268 million) before their critical design reviews. It is important to recognize that this cost trend may reverse over time, because many of the post-2010 programs are still early in production or have yet to start production.

Figure 12 provides information on these cost changes specific to the sub-portfolios of programs initiated before 2010 and since 2010.

Figure 12: Programs in DOD's 2017 Portfolio Initiated since 2010 Incurred Their Cost Growth before Critical Design Review, while Programs Initiated Prior to 2010 Incurred Most of Their Cost Growth after Production



Source: GAO analysis of Department of Defense data. | GAO-18-360SP

Note: To accommodate shipbuilding programs in this analysis, we correlated detail design contract awards, fabrication starts, and lead ship deliveries with development start, critical design review, and production start, respectively. Approximately $66 billion in cost growth occurred in programs either prior to starting system development or prior to a program being designated as a major defense acquisition program, or was included in older Selected Acquisition Reports we do not have, all of which prevented us from allocating that total in our analysis.

Four Observations on DOD's Implementation of Key Acquisition Reform Initiatives

We observed that weapon acquisition programs that consistently implement acquisition reform initiatives—such as affordability constraints, "should-cost" analyses, and acquisition strategies that promote competition throughout the lifecycle of the program—tend to gain buying power and report less cost growth on average than programs that do not implement these initiatives. This year, our analysis of 57 selected programs shows that programs have implemented measures to promote competition consistently. However, only 61 percent of programs in this year's assessment that awarded contracts for development, test, or production did so competitively. The current programs that reported implementing acquisition strategies that promote competition by awarding contracts competitively also reported less estimated total acquisition cost growth across the program, on average, than others, after accounting for quantity changes. While our analysis is limited to this assessment, the information from these programs shows a possible correlation between a reduction in estimated total acquisition cost growth and a program's use of acquisition strategies that promote competition. We also observed indications this year that the efficacy of affordability constraints and "should-cost" analyses has been reduced, although these initiatives remain largely untested. Therefore, it is premature to conclude whether the changes we observed this year will continue in the long run.

Most Programs Plan to Promote Competition during the Acquisition Process, Which Can Improve Prospects for Eventual Buying Power Gains

1. **Of the 57 current and future programs we assessed, 55 reported they intend to promote competition during the acquisition process, while 2 future programs reported they currently have no plans for competition either before or after development start.**

   Measures to promote competition that program offices reported they use, among others, include the following:

   - use of "modular open architecture", which focuses on design of highly cohesive, loosely coupled, and severable modules for a system that can be competed separately and acquired from independent vendors;
   - acquisition of the contractor's "technical data package", which may provide the government the drawings and specifications needed to produce and support the system;
   - competitive prototypes;
   - dual sources of manufacturing; and
   - competition for future upgrades.

- As we have previously found, competition is a critical tool for achieving the best return on the government's investment.[15] DOD shares this view and has reported that competition is a central tenet in acquisition reform and the single best way to motivate contractors to provide the best value.
- The two future programs with no current plans for competition—the Air Force's B-2 Extremely High Frequency Satellite Communications and UH-1N Utility Helicopter Replacement programs—could change their plans to promote competition as they move further along the acquisition process and their acquisition strategies continue to evolve.

The total of 55 programs that plan to promote competition represents an increase from last year's assessment, when only 41 programs signaled such plans. Table 6 outlines the extent to which and when current and future programs plan to promote competition.

Table 6: Plans to Promote Competition among 57 Selected Programs in DOD's 2017 Portfolio

	For the 12 future programs	For the 45 current programs	Total
Number of programs that plan to promote competition	**10**	**45**	**55**
Throughout acquisition life cycle	3	28	**31**
Only prior to start of system development	2	5	**7**
Only after the start of system development	5	12	**17**
Number of programs that do not plan to promote competition	**2**	**0**	**2**

Source: GAO Analysis of Department of Defense (DOD) data | GAO-18-360SP

2. **Sixty-one percent of programs that awarded contracts for development, test, or production reported implementing acquisition strategies that promote competition that included awarding contracts competitively. Overall, the current programs that awarded contracts competitively incurred less estimated total acquisition cost growth than others after accounting for quantity changes, both since last year and as compared to their initial cost estimates.**

[15] GAO, Defense Acquisitions: Assessments of Selected Weapon Programs, GAO-17-333SP (Washington, D.C.: Mar. 30, 2017).

DOD Instruction 5000.02 generally requires programs to have an acquisition strategy that addresses how program management will create and sustain a competitive environment, from program inception through sustainment.[16]

- Forty-six of the 57 current and future programs reported awarding contracts for product development, test, initial production, or production using either competitive or non-competitive procedures. The other 11 programs have yet to award any contracts for these types of activities as they predominately have yet to start system development.[17]
- Of these 46 programs, 28 reported awarding contracts for development, test, or production competitively, while 18 programs reported awarding contracts non-competitively.
- After controlling for quantity changes, our analysis showed that the current programs that reported implementing acquisition strategies to promote competition that included awarding competitive contracts decreased their estimated total acquisition costs by an average of $67 million since 2016. Conversely, the current programs that awarded non-competitive contracts increased their estimated total acquisition costs by an average of $50 million since 2016.
- Our analysis showed similar trends when we measured current programs against their original cost estimates. Specifically, after controlling for quantity changes, we observed an average total acquisition cost decrease of $1.01 billion for the current programs that implemented acquisition strategies to promote competition that included awarding competitive contracts. On the other hand, the current programs that reported awarding their contracts non-competitively accounted for an average total acquisition cost increase of $3.56 billion.
- One notable exception to the aforementioned reductions in estimated total acquisition costs was the DOD-wide F-35 Lightning II Joint Strike Fighter program, which awarded a competitive development contract,

[16]Programs reported awarding competitive contracts, which in some cases may have been through full and open competition pursuant to the Federal Acquisition Regulation part 6, or in other cases, may have been a more limited competition, such as a down-select competition between two contractors.

[17]For this observation, we relied on the programs self-reporting, via our questionnaire, whether or not they awarded their contracts competitively. We did not independently confirm this information as part of the analysis.

but realized significant program cost growth during development. We excluded the F-35 program from this analysis.[18]

Programs with Affordability Constraints and "Should-Cost" Analyses Report Progress with Cost Containment, but the Effectiveness of the Constraints Remains Untested

3. **Of the 57 current and future programs we assessed, 34 reported that they operate under an affordability constraint while another 23 do not. Of the 34 programs with established affordability constraints, all but one reported that they were on track to stay under their identified cost constraint.**

   DOD Instruction 5000.02 requires DOD components to develop life-cycle affordability goals early in the acquisition process, as well as affordability caps before starting system development, for major defense acquisition programs. These goals and caps, also referred to as constraints, should be stated in terms of procurement unit cost and sustainment costs.

   Affordability constraints are intended to ensure that capability requirements prioritization and cost tradeoffs occur as early as possible and throughout a program's life cycle, as well as to keep unaffordable programs from entering or remaining within the acquisition process. DOD policy instructs that when approved affordability constraints cannot be met, a program's technical requirements, schedule, and required quantities must be revisited by DOD. Under the policy, if the program still cannot meet its constraints, and DOD cannot raise the program's affordability constraints by obtaining approval to lower constraints elsewhere, the program is to be canceled.

- The 23 programs that do not have established affordability constraints include those that:
  - have not started system development,
  - were already in production prior to the affordability constraint requirement,
  - currently operate under legislatively mandated cost caps, or
  - are a nonstandard program or a development-only program with no planned procurement phase.

[18] The F-35 Lightning II Joint Strike Fighter program's approximately $118.8 billion in cost growth since its original cost estimate has an outsized effect when calculating average cost changes for groups of acquisition programs. Consequently, we excluded the F-35 program from certain analyses in this report, where noted.

- Of the 34 programs that report establishing affordability constraints, 33 of them are currently performing within their identified constraints.
    - The only program that did not report performance in line with its affordability constraints was the Air Force's Next Generation Operational Control System.
- The effectiveness of affordability constraints has yet to be widely tested, and use of affordability constraints does not preclude programs from incurring cost growth. In fact, when we excluded the DOD-wide F-35 Lightning II Joint Strike Fighter program, we observed that the other 33 programs with affordability constraints have slightly higher average cost growth from their initial estimates ($1.66 billion) than what programs without established affordability constraints have cumulatively incurred ($1.52 billion).

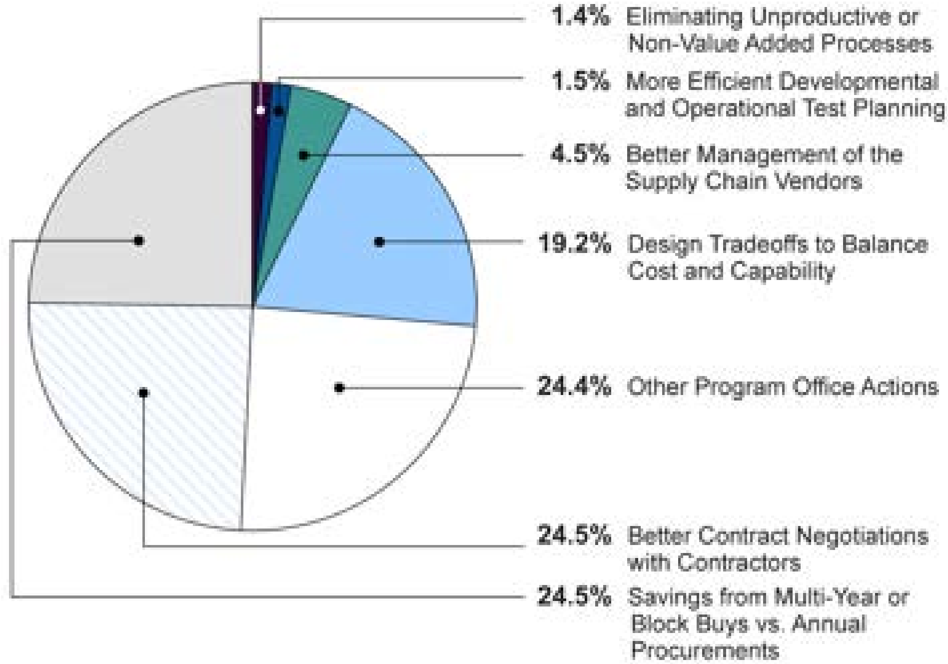
4. **Of the 57 current and future programs we assessed, 42 reported that they conducted "should-cost" analyses. These programs, along with two other programs which do not yet have approved "should-cost" targets, reported anticipated savings of $51 billion, of which $33.2 billion has been realized to date.**

   In accordance with DOD Instruction 5000.02, every major defense acquisition program should conduct a "should-cost" analysis as a management tool to help control and reduce program costs before the program starts system development.

- The aim is to scrutinize every cost under the program's control, reduce negotiated prices for contracts, and obtain other efficiencies in program execution to bring costs below what is budgeted for the program. Any savings achieved can then be reallocated within the program or for other priorities.
- Of the 45 current programs, 40 reported completing "should-cost" analyses. Of the other 5 programs, three reported that they are in the process of establishing "should-cost" targets, one reported it is using "will-cost" targets in their acquisition program baseline instead, and one programs reported being restructured and had not established new "should-cost" targets yet.
- Of the 12 future programs, only 2 reported completing a "should-cost" analysis. The other 10 programs should complete their analyses before they start system development, which is consistent with DOD policy.
- As compared to our March 2017 assessment, we observed significantly fewer anticipated savings in this year's assessment—$51 billion versus $111.5 billion.

Programs can take several different actions that lead to “should-cost” savings. Figure 13 shows the predominant actions programs take.

Figure 13: Actions Programs Reported They Have Taken to Achieve “Should-Cost” Savings



Source: GAO analysis of Department of Defense data. | GAO-18-360SP

Eight Observations from Our Assessment of Knowledge Attained by Programs at Key Junctures and Related Implications for Testing and Software Development

Our analysis of 57 selected programs shows that DOD programs continue to not fully implement knowledge-based acquisition practices. We observed several current and future programs have proceeded, or plan to proceed, into system development, through critical design reviews, and into production without meeting key acquisition practices, thereby increasing their risk of undesirable cost, schedule, and performance outcomes. At the same time, based on an exploratory statistical analysis of our previous work dating back to 2003, we observed MDAPs that implemented one or more of three specific knowledge-based acquisition practices had lower cost and schedule growth than those that did not.[19] This analysis provides additional insight as to the importance of following a knowledge-based acquisition approach, yet this pattern remains the exception, not the norm. We observed that programs frequently accept knowledge shortfalls, even if it impairs performance in the near-term, in order to produce or deliver their capability in accordance with their schedules. In addition to the shortfalls at our three knowledge points, we also observed acceptance of knowledge shortfalls in program schedules for (1) developmental testing and production, (2) software development, and (3) initial operational test and evaluation.

Most Programs Did Not Fully Demonstrate Mature Technology and Complete System Engineering Reviews before System Development Start

1. **The one program that began system development during our assessment period met all but one of the five knowledge-based acquisition practices applicable to development start. In addition, most of the 44 programs that previously began system development did not meet all knowledge-based acquisition practices.**

   The knowledge-based acquisition practices require (1) full demonstration of critical technologies, (2) completion of key systems

[19]Our exploratory statistical analysis examined eight key knowledge-based acquisition practices, which we have annually assessed individual programs on since 2003, and select programs' cost and schedule changes. We found that three of the eight key practices held a statistically significant relationship to programs' cost and schedule changes. See appendix II for more information.

engineering reviews, and (3) constraint of system development to 6 years or less. [20]

- The Navy's T-AO 205 John Lewis Class Fleet Replenishment Oiler program is a shipbuilding program, for which we measure detail design contract award as the point in system development where knowledge-based acquisition practices should be met. We observed that the T-AO 205 program fully matured all its critical technologies before it awarded a detail design contract in 2016. However, the program did not complete a preliminary design review prior to this award—an approach inconsistent with knowledge-based acquisition practices.[21]

Table 7 shows the extent to which DOD has implemented knowledge-based acquisition practices for knowledge point 1, or system development start, for the Navy's T-AO 205 program as well as for the other 44 current programs we assessed, which entered system development prior to 2017.

[20]Demonstration in a relevant environment is Technology Readiness Level (TRL) 6. Demonstration in an operational environment is TRL 7. See appendix VI for detailed descriptions of TRLs. In addition, a major defense acquisition program generally may not receive approval for development start until the milestone decision authority certifies that the technology in the program has been demonstrated in a relevant environment. 10 U.S.C. § 2366b(a)(2). Under certain circumstances, this requirement may be waived. *Id.* § 2366b(d).

[21]A major defense acquisition program generally may not receive approval for development start until the milestone decision authority has received a preliminary design review, conducted a formal assessment of the preliminary design review, and certifies, based on that assessment, that the program has a high likelihood of accomplishing its intended mission. 10 U.S.C. § 2366b(a)(1). Under certain circumstances, this requirement may be waived. *Id.* § 2366b(d).

Table 7: Implementation of Knowledge-Based Practices for Programs in System Development

Knowledge Based Practices at System Development Start	T-AO 205	Other 44 Programs ●	○	--	N/A	Trend from 2016 to 2017
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment. (TRL 6)	●	23	11	4	6	↔
Demonstrate all critical technologies in form, fit, and function within a realistic environment. (TRL 7)	●	2	31	4	7	↔
Complete system functional review and system requirements review before system development start	●	17	14	0	13	↔
Complete preliminary design review before system development start	○	21	20	0	3	↔
Constrain system development phase to 6 years or less	N/A	19	14	1	10	↓

● Practice implemented

○ Practice not implemented

-- Data not available per program response

N/A Practice Not Applicable per program response

↑ Improving Trend (increase of more than 5 percent of programs as compared to 2016)

↓ Declining Trend (decrease of more than 5 percent of programs as compared to 2016)

↔ Negligible Change (change of less than 5 percent of programs as compared to 2016)

T-AO 205 = John Lewis Class Fleet Replenishment Oiler

TRL= Technology Readiness Level

Source: GAO analysis of DOD data │ GAO-18-360SP

Notes: Three of eight key knowledge-based acquisition practices correspond with system development start. We have identified these three key practices in bold font within the table. To accommodate shipbuilding programs in this analysis, we correlated detail design contract award and lead ship fabrication start with development start and critical design review, respectively. We assessed knowledge-based acquisition practices as not applicable in situations when programs submitted responses to our questionnaire that identified events or circumstances that made completion of the practice impractical. For example, we assessed the two technology demonstration practices as not applicable in instances where a program did not have any critical technologies.

2. Of the 12 future programs scheduled to begin system development in the next few years, only one plans to fully implement all applicable knowledge-based acquisition practices.

The knowledge-based acquisition practices that programs should demonstrate before beginning system development are (1) demonstrate all critical technologies in a realistic environment, (2) complete all systems engineering reviews, and (3) constrain development to less than 6 years before starting system development.

- Only the Army's Long Range Precision Fires program plans to fully implement all applicable knowledge-based acquisition practices prior to starting development.
- Only 1 of the 12 future programs scheduled to enter system development within the next few years, the Air Force's Weather System Follow-on Microwave program, projects that it will demonstrate all its critical technologies in a realistic environment before starting development. None of the other three future programs that have identified critical technologies to date projected that they would do the same.

Table 8 shows the projected implementation of knowledge-based acquisition practices for the 12 programs we assessed that plan to start development in the next few years.

Table 8: Projected Implementation of Knowledge-Based Practices at Development Start for Future Programs

	Development Start	Projected to Demonstrate all critical technologies in a realistic environment	Projected to complete all systems engineering reviews	Plan to constrain system development to 6 years or less
Advanced Pilot Training	Spring/Summer 2018	N/A	○	●
Amphibious Ship Replacement	TBD	N/A	--	N/A
B-2 Extremely High Frequency Satellite Communications	TBD	N/A	--	--
Ground Based Strategic Deterrent	9/3/2020	○	●	--
Improved Turbine Engine Program	TBD	○	●	--
Joint Surveillance Target Attack Radar System Recapitalization	3/31/2018	○	●	●
Long Range Precision Fires	1/15/2021	N/A	●	●
MQ-25 Unmanned Aircraft System	7/30/2018	N/A	○	●
Navy Frigate	9/25/2020	N/A	○	N/A
UH-1N Utility Helicopter Replacement	N/A	N/A	○	○
VC-25B Presidential Aircraft Replacement	6/29/2018	N/A	○	○
Weather System Follow-on Microwave	3/25/2019	●	○	○

● Practice planned to be implemented

○ Practice not planned to be implemented

-- Data not available

N/A Not Applicable

Source: GAO analysis of DOD data | GAO-18-360SP

Notes: To accommodate shipbuilding programs in this analysis, we correlated detail design contract award with development start. We assessed knowledge-based acquisition practices as not applicable in situations when programs submitted responses to our questionnaire that identified events or circumstances that made completion of a practice impractical. For example, we assessed the technology demonstration practice as not applicable in instances where a program did not have any critical technologies.

Most Programs Did Not Fully Demonstrate System Design Stability Prior to Conducting Critical Design Reviews

3. Of the four programs that held critical design reviews during our assessment period, none met all of the eight associated knowledge-based acquisition practices. In addition, most of the 35 programs that previously held their critical design reviews did not meet all acquisition practices.

The eight knowledge-based acquisition practices that our prior work found programs should demonstrate prior to conducting their critical design reviews include (1) demonstration of all critical technologies in a realistic environment, (2) release of at least 90 percent of drawings to manufacturing, (3) testing of a system-level integrated prototype, (4) establishment of a reliability growth curve, (5) identification of key product characteristics, (6) identification of critical manufacturing processes, (7) completion of producibility assessments to identify manufacturing risks for key technologies, and (8) completion of failure modes and effects analysis (analysis conducted to identify failure points to improve reliability before starting hardware fabrication).

- None of the four programs—the Air Force's Combat Rescue Helicopter and F-15 Eagle Passive Active Warning Survivability System, the Army's Indirect Fire Protective Capability Increment 2-Intercept Block 1, and the Navy's Next Generation Jammer Increment 1—tested an early, integrated, system-level prototype.
- One program, the F-15 Eagle Passive Active Warning Survivability System, did not ensure at least 90 percent of its design drawings were releasable, which is inconsistent with best practices.
- Of the three programs that identified critical technologies—the Combat Rescue Helicopter, F-15 Eagle Passive Active Warning Survivability System, and Next Generation Jammer Increment 1—none ensured their critical technologies were in form, fit, and function within a realistic environment. Programs that carry technology immaturity into design and demonstration phases cannot, with certainty, validate their designs as stable until those technologies fully mature.

Table 9 shows the extent to which current DOD programs have implemented knowledge-based acquisition best practices for knowledge point 2—critical design review or, for shipbuilding programs, lead ship fabrication start. The figure highlights the aforementioned four programs that recently completed critical design reviews as well as the 35 programs that previously held their critical design reviews.

Table 9: Implementation of Knowledge-Based Practices for Selected Programs at Critical Design Review

Knowledge-based practices at critical design review	CRH	F-15 EPAWSS	IFPC Inc 2-I Blk 1	NGJ Inc 1	Other 35 Programs ●	Other 35 Programs ○	Other 35 Programs --	N/A	Trend from 2016 to 2017
Demonstrate all critical technologies in form, fit, and function within a realistic environment	○	○	N/A	○	9	17	5	4	↔
Release at least 90 percent of design drawings to manufacturing	●	○	●	●	10	17	7	1	↓
Test a system-level integrated prototype	○	○	○	○	6	21	0	8	↔
Establish a reliability growth curve	●	●	●	●	23	6	1	5	↔
Identify key product characteristics	●	●	●	●	31	0	1	3	↔
Identify critical manufacturing processes	●	●	●	●	28	1	1	5	↔
Conduct producibility assessments to identify manufacturing risks for key technologies	●	●	●	●	27	2	1	5	↔
Complete failure modes and effects analysis	●	●	●	●	29	1	1	4	↔

● Practice implemented

○ Practice not implemented

-- Data not available

N/A Practice not applicable

↑ Improving Trend (increase of more than 5 percent of programs as compared to 2016)

↓ Declining Trend (decrease of more than 5 percent of programs as compared to 2016)

↔ Negligible Change (change of less than 5 percent of programs as compared to 2016)

CRH = Combat Rescue Helicopter

F-15 EPAWSS = F-15 Eagle Passive Active Warning Survivability System

IFPC Inc 2-I Blk 1 = Indirect Fire Protective Capability Increment 2-Intercept Block 1

NGJ Inc 1 = Next Generation Jammer Increment 1

Source: GAO analysis of DOD data │ GAO-18-360SP

Notes: Two of eight key knowledge-based acquisition practices correspond with critical design review. We have identified these two key practices in bold font within the table. To accommodate shipbuilding programs in this analysis, we correlated detail design contract award and lead ship fabrication start with development start and critical design review, respectively. We assessed knowledge-based acquisition practices as not applicable in situations when programs submitted responses to our questionnaire that identified events or circumstances that made completion of the practice impractical. For example, we assessed the technology demonstration practice as not applicable in instances where a program did not have any critical technologies.

None of the Programs Fully Demonstrated Manufacturing Processes Were in Statistical Control Prior to Starting Production

4. Of the three programs that held a production decision during our assessment period, only one met all applicable knowledge-based acquisition practices. In addition, none of the 18 non-shipbuilding programs that previously began production met all acquisition practices.

The five knowledge-based acquisition practices that our prior work found programs should demonstrate prior to starting production are (1) demonstration of all critical technologies in a realistic environment, (2) release of at least 90 percent of drawings to manufacturing, (3) demonstration that critical manufacturing processes are in statistical control, (4) demonstration of critical processes on a pilot production line, and (5) testing of a production-representative prototype in its intended environment. The third knowledge-based acquisition practice listed above is to ensure that all critical manufacturing processes are in statistical control—that is, they are repeatable, sustainable, and capable of consistently producing parts within quality tolerances and standards—at the start of production.

- One program, the Navy's MQ-8 Fire Scout, demonstrated all knowledge-based acquisition practices for all applicable practices. Based on the program's responses that it has no critical technologies and uses metrics other than manufacturing readiness levels or statistical measures to track manufacturing readiness, we assessed the program as not applicable for those two practices. We also assessed the Navy's Air and Missile Defense Radar program as not applicable for demonstrating critical processes on a pilot production line based on its response.
- Two of the three programs, the Navy's CH-53K Heavy Lift Replacement Helicopter and Air and Missile Defense Radar, did not demonstrate their critical manufacturing processes were in statistical control prior to starting production.
- Two out of the three programs—the Navy's CH-53K Heavy Lift Replacement Helicopter and MQ-8 Fire Scout—demonstrated critical processes on a pilot production line. These programs also tested production representative prototypes in their intended environments.

Table 10 shows the extent to which DOD implemented knowledge-based acquisition practices for knowledge point 3, or production start, for the three aforementioned programs that recently held production reviews, as well as the other 18 non-shipbuilding programs we assessed that entered production prior to 2017. We do not assess shipbuilding programs for this knowledge point due to difference in the production processes used to construct ships.

Table 10: Implementation of Knowledge-Based Practices for Selected Programs at Production Decision

				For the 18 Non-shipbuilding programs that have reached this juncture				
Knowledge Based Practices at Production Decision	**AMDR**	**CH-53K**	**MQ-8 Fire Scout**	**●**	**○**	**--**	**N/A**	**Trend from 2016 to 2017**
Demonstrate all critical technologies in form, fit, and function within a realistic environment	○	●	**N/A**	**12**	**4**	**2**	**0**	↔
Release at least 90 percent of design drawings to manufacturing	●	●	●	**8**	**5**	**2**	**3**	↔
Demonstrate Manufacturing Readiness Level of at least a 9 or critical processes are in statistical control	○	○	**N/A**	**0**	**15**	**0**	**3**	↓
Demonstrate critical processes on a pilot production line	**N/A**	●	●	**9**	**5**	**0**	**4**	↔
Test a production-representative prototype in its intended environment	○	●	●	**6**	**9**	**0**	**3**	↔

● Practice implemented

○ Practice not implemented

-- Data not available

N/A Practice not applicable

↑ Improving Trend (increase of more than 5 percent of programs as compared to 2016)

↓ Declining Trend (decrease of more than 5 percent of programs as compared to 2016)

↔ Negligible Change (change of less than 5 percent of programs as compared to 2016)

CH-53K = Heavy Lift Replacement Helicopter (CH-53K)

AMDR = Air and Missile Defense Radar (AMDR)

Source: GAO analysis of DOD data │ GAO-18-360SP

Notes: Three of eight key knowledge-based acquisition practices correspond with production decision. We have identified these three key practices in bold font within the table. We assessed knowledge-based acquisition practices as not applicable in situations when programs submitted responses to our questionnaire that identified events or circumstances that made completion of the practice impractical. For example, we assessed the technology demonstration practice as not applicable in instances where a program did not have any critical technologies.

Exploratory Analysis Suggests that Certain Knowledge-Based Acquisition Practices Correspond with Better Acquisition Outcomes

5. **We found that, on average, MDAPs that completed some or all of the following three actions had lower cost increases than other programs:**

- **demonstrated all critical technologies were very close to final form, fit, and function, within a relevant environment, before starting development;**[22]
- **held a preliminary design review prior to starting development; and**
- **released at least 90 percent of their design drawings by critical design review.**

Additionally, we found that MDAPs that held a preliminary design review prior to starting development had less schedule growth than other programs.

We analyzed 15 programs that already completed system development, held a critical design review, and started production (i.e., completed knowledge points 1 through 3). These programs, 2 of which we included in our first annual assessment in 2003, were ones that we had previously assessed at the time they completed each knowledge point for their implementation of the correspondent knowledge-based acquisition practices.

- Our analysis revealed that, on average, programs that completed one or more of the aforementioned three knowledge-based acquisition practices had lower cost increases than programs that did not complete these knowledge-based practices by the time they reached each knowledge point.[23] These differences, which ranged from

[22]GAO's best practices work has shown that a Technology Readiness Level (TRL) 7—which corresponds to demonstrating all critical technologies in form, fit, and function within a realistic environment—is the level of technology maturity that constitutes a low risk for starting development. DOD's policy, however, permits development to start at a lower technology maturity level—TRL 6, which corresponds to demonstrating technology in a relevant environment. DOD's policy is based on a statute that generally prohibits a major defense acquisition program from receiving approval for development start until the milestone decision authority certifies—based on an independent review and technical risk assessment—that the technology in the program has been demonstrated in a relevant environment. 10 U.S.C. § 2366b(a)(2). Although GAO included both TRL 6 and 7 in the knowledge-based acquisition practices exploratory statistical analysis, only one program in the sample achieved TRL 7 before starting development, which was not enough to assess whether this practice corresponded with lower cost and schedule growth.

[23]We conducted a means test comparing averages across systems that did and did not complete knowledge-based acquisition practices using a 95 percent confidence level. See Appendix II for additional details.

approximately 56 to 63 percentage points lower on average for cost increases, were statistically significant.

- Additionally, programs that held a preliminary design review prior to starting development had 47 percent less schedule growth than programs that did not.
- These results support our work and offer initial validation that MDAPs that follow these particular knowledge-based practices may have lower cost increases and less schedule growth than those programs that do not.
- Because inferences from our analysis were limited by the small sample size and the unique characteristics of the 15 MDAPs in the data set, we plan to update this analysis in our future annual assessments. As more programs we previously assessed at development start and at critical design review enter production, this larger sample may enable more precise analysis of differences between MDAPs that completed or did not complete specific knowledge-based practices.

Our prior work demonstrates that completion of all of the knowledge-based practices by the time programs reach their knowledge points underpins a sound business case that positions programs to better meet their cost and schedule goals.

Programs Often Enter Production with Incomplete Knowledge, Which Contributes to Cost and Schedule Growth

6. **Of the 45 current programs we reviewed, 23 reported schedules that included overlap, or concurrency, between developmental tests and production. We observed that this concurrency was accompanied by higher acquisition cost growth, not attributable to quantity changes, as compared to 8 other programs.**

   We observed that cost growth over the last year averaged $513 million not attributable to quantity changes for the 23 programs with concurrent schedules and $154 million for each of the 8 programs reporting non-concurrent schedules.

- We also observed total acquisition cost growth since first full estimate not attributable to quantity changes averaged $6.05 billion from the first full estimates of the 23 programs with concurrent schedules and $689 million from the first full estimates of the 8 programs reporting non-concurrent schedules.

We excluded 14 current programs from this analysis. These programs constituted development-only programs without a production phase, were shipbuilding programs with uniquely structured developmental test schedules, or, in a few cases, did not identify specific dates for production start or developmental tests, which precluded us from assessing them for concurrency.

7. **Of the 45 current programs we assessed, 18 completed, or plan to complete, software development activities after production start, which increases the risk of cost growth, schedule delays, and capability limitations.**

   In our previous best practices work, we found that leading commercial companies that develop products attain key knowledge about software before production begins.[24]

- We have also identified DOD programs that incurred cost and schedule growth when software development activities extended into the production phase.
  - One prominent example of this is the DOD-wide F-35 Lightning II Joint Strike Fighter program, which began low rate initial production in 2007, but—a decade later—has yet to complete its software development activities.[25]
  - Other programs we assessed this year that are currently in production and have reported problems with software development are the Air Force's Small Diameter Bomb Increment II as well as the Navy's Ground/Air Task-Oriented Radar.
- Programs that defer completion of software development activities to post-production phases—such as after initial operational capability or initial operational test and evaluation—risk delivering systems to the warfighter that do not meet their minimum performance requirements.

Figure 14 shows when in development or production the 45 current programs we assessed completed, or plan to complete, software development.

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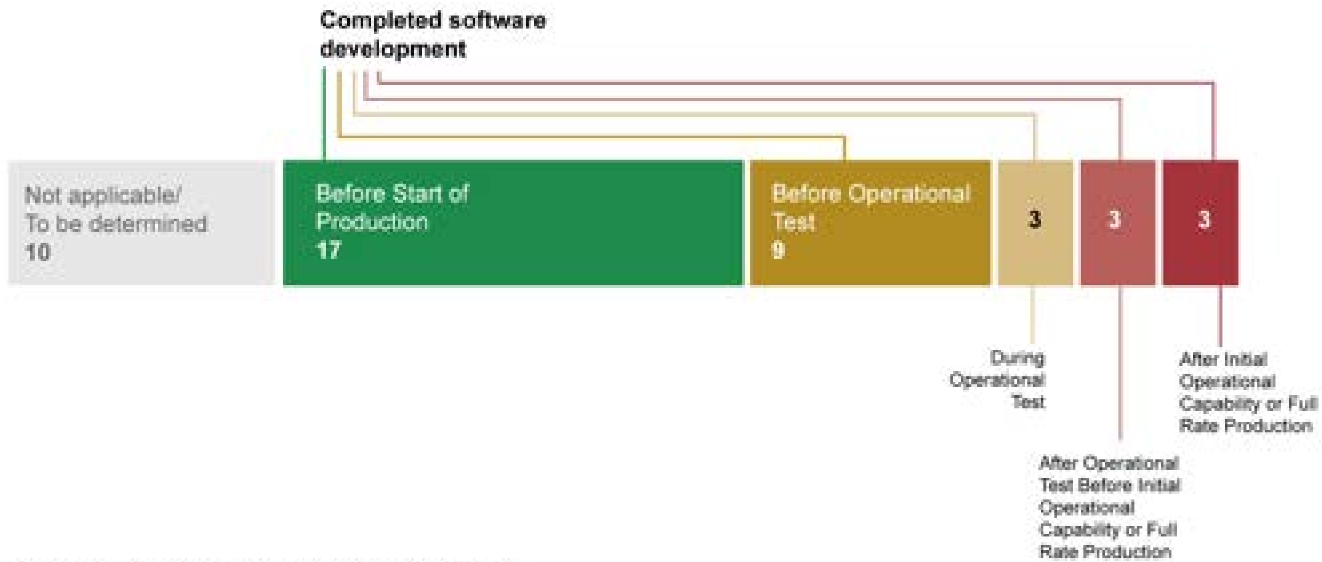
[24]GAO, *Defense Acquisitions: Stronger Management Practices Are Needed to Improve DOD's Software-Intensive Weapon Acquisitions,* GAO-04-393 (Washington, D.C.: Mar. 1, 2014).

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

Figure 14: Eighteen Current Programs Completed, or Plan to Complete, Software Development after Production Start



Source: GAO analysis of Department of Defense data. | GAO-18-360SP

Knowledge from Operational Testing Is Often Not Prerequisite to DOD Declaring a Weapon System Capable to Conduct Operations

8. Over one-third of the 45 current programs we assessed declared, or intend to declare, initial operational capability on the basis of limited or, in a few cases, no initial operational test and evaluation.

Initial operational capability occurs when a unit or organization has been equipped and trained and is determined to be capable of conducting operations with a newly fielded system.

- Initial operational test and evaluation is a separate event that is intended to evaluate a system's effectiveness and suitability under realistic operational conditions before a program makes a full-rate production decision.
- Consequently, programs can declare initial operational capability on the basis of full, partial, or no initial operational test and evaluation.
- We observed that 5 programs declared, or plan to declare, initial operational capability before initial operational test and evaluation begins. Another 11 programs declared, or plan to declare, this capability before the testing completes.
    - Programs that declare initial capability before completing initial operational test and evaluation risk fielding systems to warfighters that are not operationally effective or suitable for the missions they will be tasked to perform.

- These totals represent a significant change over last year's assessment, which we attribute in part to additional visibility we gained into programs' operational test schedules, which improved our analysis.

Figure 15 details our analysis of the relationship between initial operational capability and initial operational test and evaluation in 45 current selected DOD programs.

Figure 15: Sixteen Programs Declared or Plan to Declare Initial Operational Capability before Completing Initial Operational Test and Evaluation

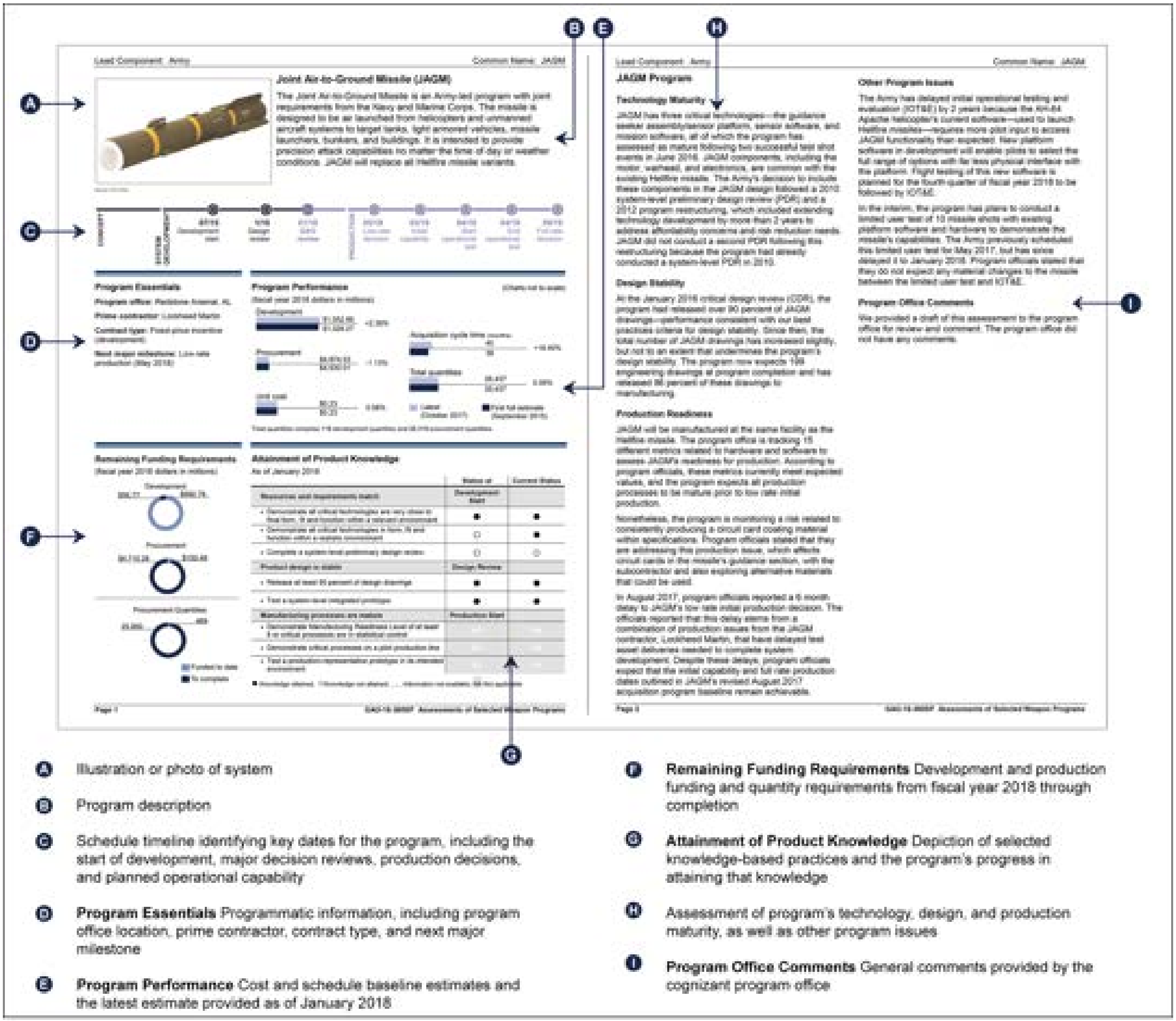
Source: GAO analysis of Department of Defense data. | GAO-18-360SP

Assessments of Individual Programs

This section contains assessments of individual weapon programs grouped by lead service—Army, Navy and Marine Corps, Air Force, and DOD-wide—and includes a lead service separator page at the start of each grouping. Each assessment presents data on the extent to which programs are following a knowledge-based acquisition approach to product development. Each lead service separator page summarizes information about the acquisition phase, current estimated funding needs, cost and schedule growth, and product knowledge attained. In total, we present information on 57 programs.

For 42 programs, we produced two-page assessments discussing the technology, design, and manufacturing knowledge obtained, as well as other program issues. Each two-page assessment contains a comparison of total acquisition cost from the first full estimate for the program to the current estimate. The first full estimate is generally the cost estimate established at development start; however, for a few programs that did not have such an estimate, we used the estimate at production start. For shipbuilding programs, we used their planning estimates if those estimates were available. For programs that began as non–major defense acquisition programs, we used the first full estimate available. Of these 42 two-page assessments, most are in development or early production. See figure 16 for an illustration of the layout of each two-page assessment.

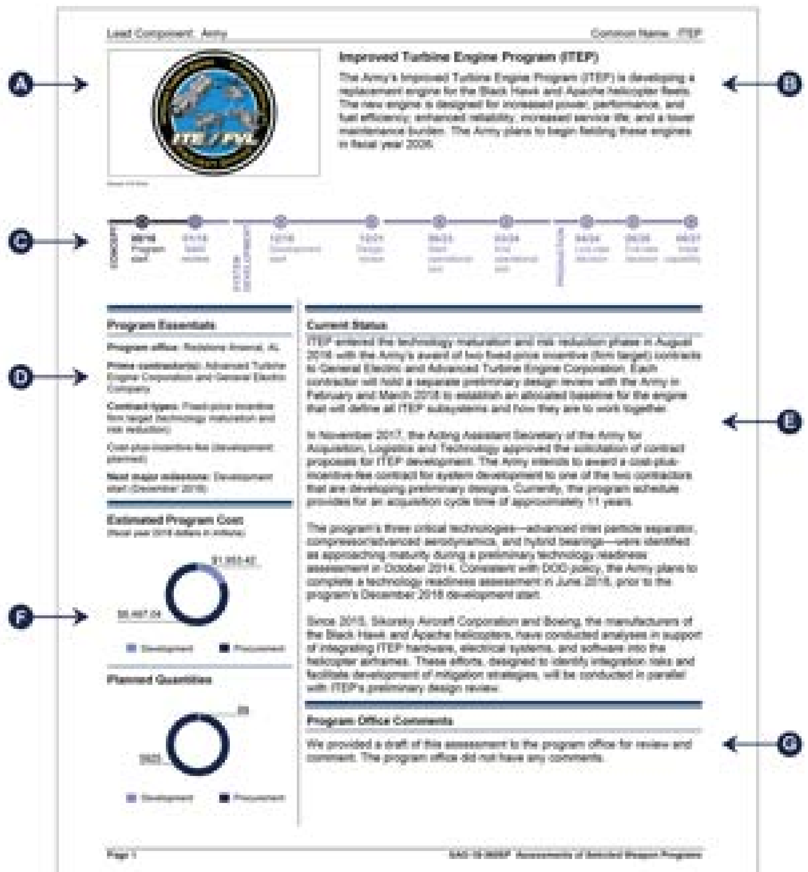
Figure 16: Illustration of Program Two-Page Assessment



Source: GAO analysis. | GAO-18-360SP

In addition, we produced one-page assessments on the current status of 15 programs, which include 12 future major defense acquisition programs and 3 major defense acquisition programs that are well into production, but are developing new increments of capability as part of their existing programs. See figure 17 for an illustration of the layout of each one-page assessment.

Figure 17: Illustration of Program One-Page Assessment



- **A** Illustration or photo of system
- **B** Program description
- **C** Schedule timeline identifying key dates for the program, including the start of development, major decision reviews, production decisions, and planned operational capability
- **D** **Program Essentials** Programmatic information, including program office location, prime contractor, contract type, and next major milestone
- **E** **Current Status** Updated status of program
- **F** **Estimated Program Cost** Current estimated funding needs and quantity requirements
- **G** **Program Office Comments** General comments provided by the cognizant program office

Source: GAO analysis. | GAO-18-360SP

For our two-page assessments, we use a scorecard to depict the extent of knowledge gained. These scorecards display key knowledge-based acquisition practices that should be implemented by certain points in the acquisition process. The more knowledge the program has attained by each of these key points, the more likely the weapon system will be delivered within its estimated cost and schedule. A knowledge deficit means the program is proceeding without sufficient knowledge about its technologies, design, or manufacturing processes, and faces unresolved risks that could lead to cost increases and schedule delays.

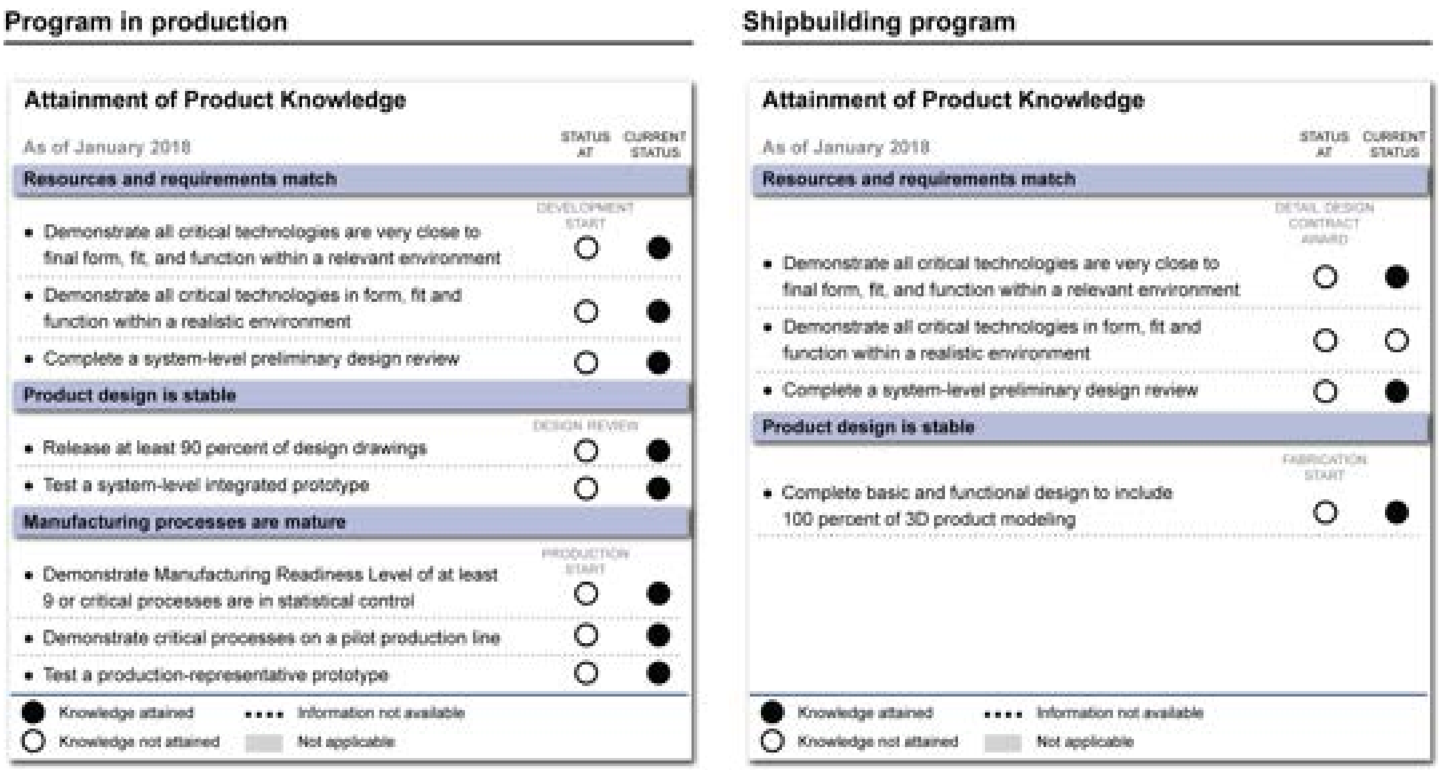
For each program, we identified a knowledge-based practice that had been implemented with a closed circle. We identified a knowledge-based practice that had yet to be implemented with an open circle. If the program did not provide us with enough information to make a determination, we showed this with a dashed line. A knowledge-based practice that is not applicable to the program is grayed out. A knowledge-based practice may not be applicable to a particular program if the point in the acquisition cycle when the practice should be implemented has yet to be reached, or if the particular practice is not relevant to the program. For programs that have yet to enter system development, we show a projection of knowledge attained for the first three practices. For programs that have entered system development but have yet to hold a critical design review, we assessed actual knowledge attained for these three practices. For programs that have held a critical design review but have yet to enter production, we assessed knowledge attained for the first five practices. For programs that have entered production, we assessed knowledge attained for all eight practices.

For shipbuilding programs, we assessed different key points in the acquisition cycle and applicable knowledge-based practices, which were informed by our prior work.[26] For shipbuilding programs that have yet to award a detail design contract, we showed a projection of knowledge attained for the first three practices. For shipbuilding programs that have awarded this contract but have yet to start construction, we assessed actual knowledge attained for these three practices. For shipbuilding programs that have started construction, we assessed the knowledge attained for the first four practices. We did not assess the remaining four practices that correspond with knowledge point 3 for shipbuilding programs as our prior work has found that these are not applicable to

[26]GAO-09-322.

these programs. See figure 18 for examples of the knowledge scorecards we use to assess these different types of programs.

Figure 18: Examples of Knowledge Scorecards



Source: GAO. | GAO-18-360SP

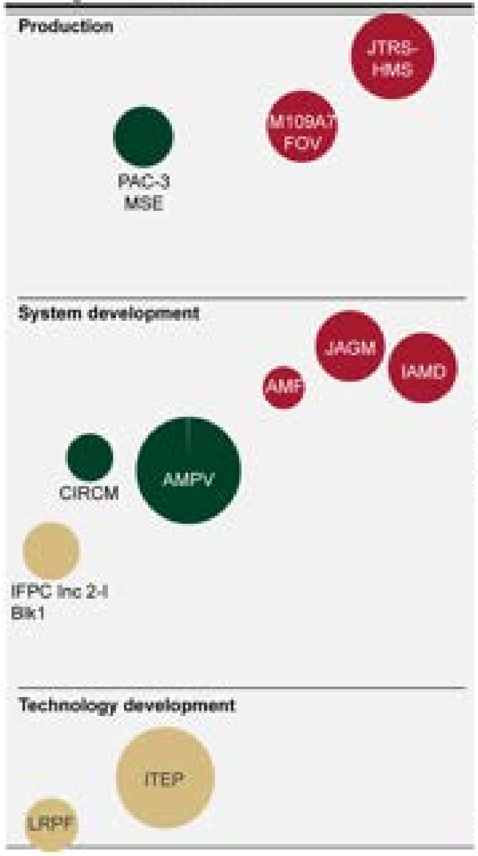
Army Program Assessments

We completed individual assessments on 11 of the Army's 24 current and future major defense acquisition programs. Of these 11 programs, 9 are in either system development or early production while 2 are future programs that DOD expects to enter system development in the next few years. We found the Army currently estimates a need of $55 billion to complete the acquisition of these 11 programs. We also compared these programs' first full estimates of cost and schedule with their current estimates and found that:

- net cost reduction totals $6.6 billion, the majority of which occurred more than 5 years ago, and
- program schedule delays average approximately 32 months.

Only three of the 11 programs—AMPV, CIRCM, and PAC-3 MSE—completed all activities associated with the applicable knowledge-based best practices we assess, although these activities were not fully complete at the time the knowledge points were reached.

Acquisition Phase and Size of the 11 Programs Assessed



Cost growth of more than 15 percent and/or schedule delays of more than 6 months

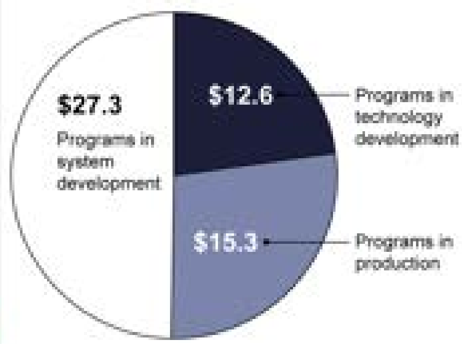
Cost growth of 15 percent or less and schedule delays of 6 months or less

No first full estimate available

Note: Bubble size is based on each program's currently estimated future funding needed.

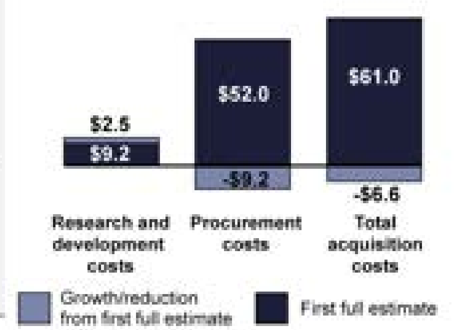
Currently Estimated Acquisition Costs for the 11 Programs Assessed

Fiscal year 2018 dollars in billions



Cost and Schedule Growth on 8 Programs in the Current Portfolio

Fiscal year 2018 dollars in billions



Note: For acquisition cycle time, only 7 programs were assessed as not all programs contained sufficient information within their first full estimates to determine acquisition cycle time. In addition to research and development and procurement costs, total acquisition cost includes acquisition-related operation and maintenance and system-specific military construction costs.

Summary of Knowledge Attained to Date for Programs Beyond System Development Start

Program common name	Knowledge Point (KP) 1 Resources and requirements match: At KP1	Current Status	Knowledge Point 2 Product design is stable: At KP2	Current Status	Knowledge Point 3 Manufacturing processes are mature: At KP3	Current Status
AMF	○	N/A	●	N/A	N/A	N/A
AMPV	○	●	○	●	KP 3 in future	
CIRCM	○	●	●	●	KP 3 in future	
IAMD	○	●	○	○	KP 3 in future	
IFPC	●	●	○	○	KP 3 in future	
JAGM	○	○	●	●	KP 3 in future	
JTRS-HMS	○	N/A	○	N/A	○	N/A
M109A7	○	●	○	●	○	○
PAC-3 MSE	○	●	○	●	○	●

● All applicable knowledge practices completed

○ One or more applicable knowledge practices were not completed

N/A Knowledge practice is not applicable

- - - Information not available for all applicable knowledge practices

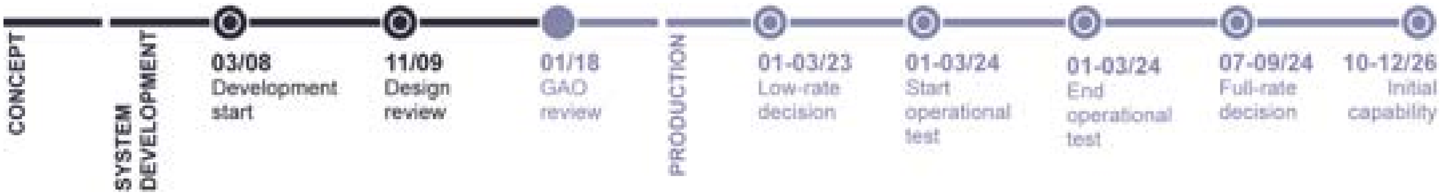
Source: GAO analysis of DOD data. | GAO-18-360SP

Army Program Assessments

Source: U.S. Army.

Airborne and Maritime/Fixed Station (AMF)

The Army's AMF program plans to acquire non-developmental, software-defined radios—named the Small Airborne Networking Radio (SANR)—and associated equipment for integration into Army rotary wing and unmanned aerial systems. These two-channel radios will provide simultaneous voice and data communications between Army platforms and ground forces.



Program Essentials

Program office: Aberdeen Proving Ground, MD

Prime contractor: TBD

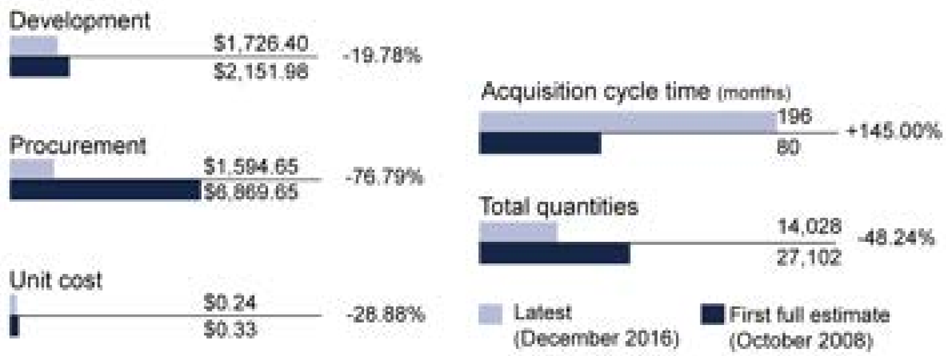
Contract type: TBD

Next major milestone: Low-rate initial production (January to March 2023)

Program Performance

(Charts not to scale)

(fiscal year 2018 dollars in millions)



DOD reports AMF quantities in the total number of channels, rather than radios, that it plans to acquire. Two channels (quantities) equates to one SANR radio.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	●	NA
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	NA
• Complete a system-level preliminary design review	●	NA
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	●	NA
• Test a system-level integrated prototype	●	NA
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	NA	NA
• Demonstrate critical processes on a pilot production line	NA	NA
• Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

AMF Program

Technology Maturity, Design Stability, and Production Readiness

The AMF program office plans to purchase technically mature, production-ready SANR radios from an as-yet to be determined contractor. This non-developmental acquisition strategy, which the Army adopted in 2012, does not lend itself to application of our standard metrics for technology maturity, design stability, and production readiness. We have updated our attainment of product knowledge table to reflect this change compared to what we presented in our 2017 assessment.

The AMF program's acquisition strategy had its genesis in 2012 when, as part of an overall Joint Tactical Radio System (JTRS) program reorganization, DOD directed the AMF program to acquire the radios as a modified non-developmental item. DOD further directed that the AMF program leverage, to the maximum extent practicable, investments made since 2008 within the original JTRS program. The restructure shifted the program from a development effort supporting Army, Air Force, and Navy platforms to a non-developmental effort supporting only Army aviation.

The program office's procurement of radios is currently in the pre-solicitation phase before award of a production contract. The office anticipates that it will solicit proposals from potential contractors in the fourth quarter of fiscal year 2018 and award a contract in the third quarter of fiscal year 2020. It plans to procure 7,014 two-channel SANR radios total—110 for test purposes; 262 as part of low-rate initial production; and 6,642 in full-rate production.

The program office believes that its revised acquisition strategy provides opportunities for it to assess technology maturity, design stability, and production readiness. Those opportunities, it stated, include plans to require contractors to identify critical technology elements prior to contract award, substantiate contractors' claims with their test results, and submit manufacturing plans that detail the contractor's readiness to produce radios that meet Army requirements and schedule. Additionally, the program office expects to use other methods after contract award to ensure the chosen contractor's radios meet Army needs, such as a re-assessment of technology maturity in tests prior to the low-rate initial production decision, use of contract terms to control changes to design, and tests that demonstrate the production process.

Other Program Issues

Since our 2017 assessment, the Army has delayed the AMF initial capability by over 3 years. This delay, coupled with prior delays, has increased the program's schedule to over 18.5 years between development start and initial capability—for what is now ostensibly a non-developmental acquisition. According to program officials, Army leadership has yet to approve the program's plans for SANR production, testing, and deployment. The program expects that the ongoing Army network review, which was established to adjust and modernize Army communications programs, will produce changes to current AMF acquisition plans. Already, program officials stated that AMF's current schedule estimate will breach the program's 2014 approved baselines for full rate production and initial operational capability and as a result, the Army will need to approve a new program baseline once the network review and a related analysis of alternatives are complete.

The Army's network analysis could also affect the AMF program schedule in other ways. According to program officials, the analysis could recommend the replacement of a currently planned SANR voice and data waveform with another waveform. The officials stated that should the Army adopt a waveform change, the program will require additional time to adjust the program's content and schedule.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office did not have any comments.

Source: U. S. Army

Armored Multi-Purpose Vehicle (AMPV)

The Army's Armored Multi-Purpose Vehicle (AMPV) is the replacement to the M113 family of vehicles at the Brigade level and below. The AMPV will replace the M113 in five mission roles: general purpose, medical evacuation, medical treatment, mortar carrier, and mission command. The Army determined that development of the AMPV is necessary due to mobility, survivability, and force protection deficiencies identified with the M113, as well as space, weight, power, and cooling limitations that prevent the incorporation of future technologies.

Program Essentials

Program office: Warren, MI

Prime contractor: BAE Systems

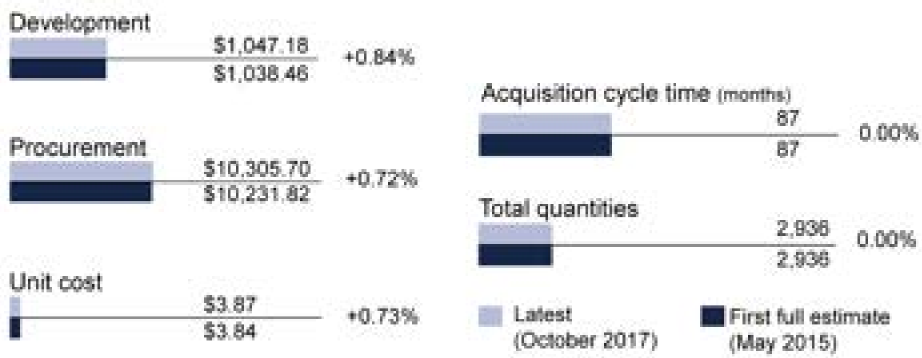
Contract type: Cost-plus-incentive-fee (development)

Next major milestone: Low-rate initial production (February 2019)

Program Performance

(Charts not to scale)

(fiscal year 2018 dollars in millions)



Total quantities comprise 39 development quantities and 2,897 procurement quantities.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	●	●
• Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	○	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	NA	NA
• Demonstrate critical processes on a pilot production line	NA	NA
• Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

AMPV Program

Technology Maturity and Design Stability

The AMPV program entered system development in December 2014 with its critical technologies deemed fully mature by an independent review team. According to program officials, while the AMPV design utilizes a new hull design, a majority of subsystems are derived from existing vehicle designs.

The program held its critical design review in June 2016 with over 90 percent of its design drawings released to manufacturing, but it had not demonstrated a system-level prototype at that time. Following CDR, however, the total number of drawings unexpectedly grew by nearly 19 percent as the contractor underestimated the number and complexity of design drawings needed to meet program requirements, thus undermining the design stability the program thought it had attained. We have updated our attainment of product knowledge table to reflect this change in design stability from our previous assessment. We currently assess the AMPV design as stable because the program reports that it has released all planned drawings to manufacturing.

The program's plan to complete a planned logistics demonstration prior to production start has fluctuated because of program challenges. This demonstration—which was intended to demonstrate that the vehicle's design could meet maintainability requirements and was stable before commencing low-rate initial production—was initially postponed after the contractor delivered the AMPV technical data package over a year late, in large part due to the late release of engineering drawings. The program was at risk for fully completing this demonstration after the start of production. According to program officials, however, the contractor's new recently completed plan anticipates completion of the logistics demonstration prior to the start of production.

Production Readiness

The contractor, BAE Systems, delivered the first prototype in December 2016. While this vehicle was delivered on time, subsequent prototype deliveries have been delayed by as much as 3 months due to problems with parts shortages and changes to engineering drawings, among other things. Due to delayed prototype deliveries, the program eliminated initial contractor-specific performance and reliability testing. The current test schedule has relatively little margin to account for discovery and correction of any vehicle deficiencies.

According to program officials, the program plans to demonstrate its critical manufacturing processes on a pilot production line prior to the start of low-rate initial production in February 2019. Program officials noted that the contractor should deliver all prototypes by the end of calendar year 2017, which would provide the program with over a year to refine manufacturing activities prior to the start of production. According to program officials, this would include redesigning the manufacturing layout based on prototype building issues. However, in a series of program assessment reports, the Defense Contract Management Agency (DCMA) identified significant concerns about the contractor's capabilities for collecting and assessing manufacturing process control data. Specifically, in a November 2017 overall program status assessment provided by the program manager, DCMA reported that the contractor did not have adequate production controls in place to sufficiently evaluate production processes.

Other Program Issues

The program has experienced development contract cost growth of over 20 percent above target cost due to continued challenges meeting logistics, performance, and production requirements. However, program officials noted that the government's official cost position for AMPV development—based on the independent cost estimate prepared by the Office of Cost Assessment and Program Evaluation—has not changed as it includes adequate margin to account for the cost growth to date.

AMPV remains dependent on other programs—such as the Army's Handheld, Manpack, and Small Form Fit Radios—for its key communication and networking capabilities. However, these programs have experienced their own acquisition challenges delaying their availability for the AMPV program. The program is including a legacy radio platform in its production vehicle design configuration, which will, according to program officials, readily accommodate future networking capabilities provided by these other programs.

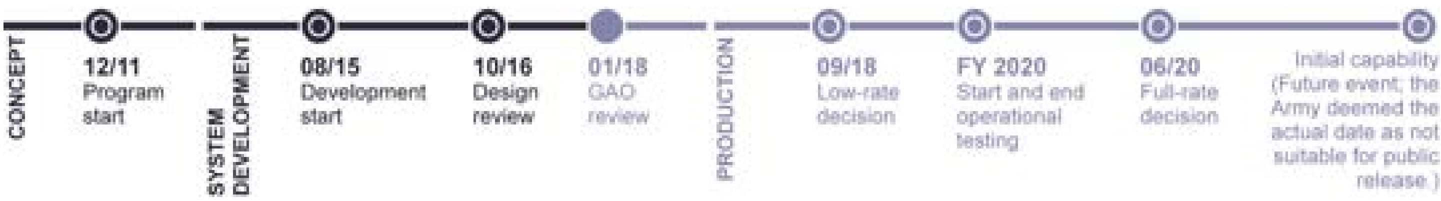
Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. Program officials also noted that the program remains within its cost, schedule, and performance baseline. They said that the cost rebaseline process is complete, and there are sufficient resources for remaining work. They also stated that they judge the vehicle design to be stable based on drawing releases, prototype deliveries, and initial reliability test results. According to the program office, prototype deliveries were on average 6-8 weeks behind schedule, but the program stated that it has minimized delays through a compressed test schedule that has merged contractor tests into the government test program. Additionally, the program said that vehicle reliability, availability, and maintainability tests have exceeded the number of miles planned per day, which has further reduced lost time. The program also reported that the contractor is updating its production process in order to minimize variability and risk.

Source: Northrop Grumman Systems Corporation

Common Infrared Countermeasure (CIRCM)

The Army's CIRCM is the next generation lightweight, laser-based infrared countermeasure system for rotary-wing, tilt-rotor, and small fixed-wing aircraft across DOD. CIRCM will consist of a laser tracker that interfaces with the Army's Common Missile Warning System and a countermeasure dispenser that deploys decoys, such as flares and chaff. Prior to April 2009, CIRCM was a subprogram under the Army's Advanced Threat Infrared Countermeasures/Common Missile (ATIRCM) Warning System program, but is currently being developed to replace ATIRCM.



Program Essentials

Program office: Huntsville, AL

Prime contractor: Northrop Grumman

Contract type: Cost-plus-fixed-fee/fixed-price incentive fee/firm-fixed-price (development)

Next major milestone: Low-rate initial production (September 2018)

Program Performance

(Charts not to scale)

(fiscal year 2018, dollars in millions)

Total quantities comprise 48 development quantities and 1,076 procurement quantities.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	●	●
• Test a system-level integrated prototype	●	●
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	NA	NA
• Demonstrate critical processes on a pilot production line in a realistic environment	NA	NA
• Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

CIRCM Program

Technology Maturity and Design Stability

The CIRCM program office reported that the system's six critical technologies are fully mature and nearly 100 percent of all expected drawings are complete. In our 2017 assessment, we reported that CIRCM had nine critical technologies that were approaching maturity. However, three of those technologies were unique to the design of a contractor, BAE Systems, which is not continuing into Engineering and Manufacturing Development. For the six remaining critical technologies, the program increased their maturity levels by integrating the system onto an Army aircraft and completing the initial testing, which demonstrated that the technologies perform in a realistic environment.

At its October 2016 critical design review, the CIRCM program had released 97 percent of its planned design drawings, which constitutes a stable design. However the CIRCM has yet to meet its reliability requirement and changes to design could be necessary. In April 2017, the DOD Inspector General found that the CIRCM requirements documents and test plan did not require demonstration of minimum reliability requirements until after the program's full-rate production decision. Specifically, the Inspector General found that the program's approved requirements documents and test plans show that CIRCM is scheduled to enter full-rate production after it has demonstrated only 70 percent (150 hours) of its 214 hour requirement for mean time between operational mission failures. The Inspector General subsequently recommended that the Army revisit and improve its CIRCM requirements and test plans before the system enters production. The Program Executive Officer for Intelligence, Electronic Warfare, and Sensors (PEO IEW&S), who oversees CIRCM, concurred with the Inspector General's recommendation.

Production Readiness

The program is identifying critical manufacturing processes at production readiness reviews. These reviews are scheduled to be completed in April 2018. Prototype and production-representative articles have already been built. Full-rate production will use the same equipment, stations, processes, and personnel as the production-representative items to demonstrate manufacturing capabilities on a pilot production line before CIRCM enters production. Program officials stated that CIRCM is now ready to move into the production phase, based on test results from the system's integration onto an Army aircraft and completion of contractor flight testing activities. In 2017, the Army conducted testing at Redstone Arsenal to demonstrate CIRCM in a production configuration on the aircraft as well as performance while exposed to motion, vibration, and electromagnetic environments specific to the aircraft. The tests provided information on CIRCM capabilities to acquire, track, point and emit laser energy in various environments.

Despite the Army's assertion that the program is ready for production, it has postponed its planned production decision for CIRCM from March 2018 until September 2018 due to schedule delays experienced during system development. These delays resulted from late deliveries of key CIRCM components, including system processor units, lasers, and pointers/trackers, as well as from reliability test failures.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. According to program officials, poor performance by the prime contractor and its subcontractors, sub-tier manufacturing and quality problems, and higher-than-anticipated reliability failures resulted in a 6-month delay to the low-rate initial production decision, which is now scheduled for September 2018. The program stated that, in response to the aforementioned shortfalls, PEO IEW&S established a committee to oversee improvements to CIRCM reliability. It also stated that the program successfully conducted testing in the first quarter of fiscal year 2018 to demonstrate reliability improvements to date. Officials further stated that the program addressed hardware delivery delays as part of a comprehensive corrective action plan that the committee developed. Per program officials, they have realigned CIRCM hardware deliveries to account for the 6-month delay and to support upcoming reliability demonstration and flight testing events.

Source: © 2012 General Dynamics C4S.

Handheld, Manpack, and Small Form Fit Radios (HMS)

The Army's HMS program seeks to develop software-defined radios to connect with existing radios and increase communications and networking capabilities. The program continues efforts begun under the former Joint Tactical Radio System program to procure two radios—the Leader (formerly Rifleman) and Manpack radios. A subset of Manpack radios is designed to operate with the Mobile User Objective System (MUOS)—a Navy satellite communication system planned to serve a worldwide, multiservice population of mobile and fixed-site terminal users. In 2017, the Army truncated its acquisition of one-channel Rifleman radios in favor of two-channel Leader radios.

Program Essentials

Program office: Aberdeen Proving Ground, MD

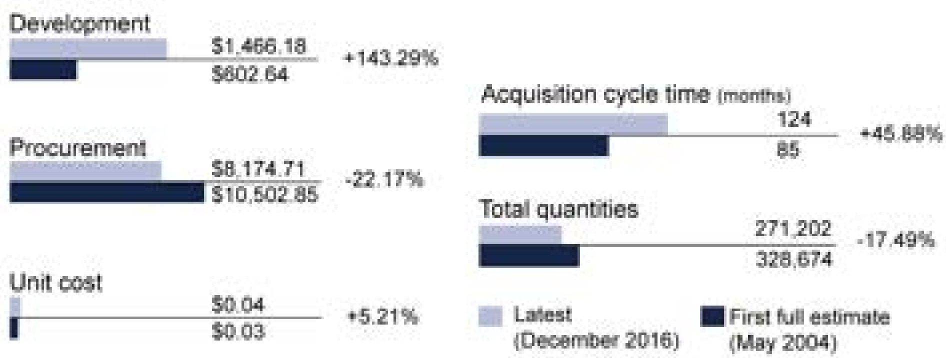
Prime contractors: Harris Corporation; Thales Defense and Security; Rockwell Collins

Contract type: Firm-fixed-price (production)

Next major milestone: Full-rate production decision—Manpack radio (February 2021)

Program Performance

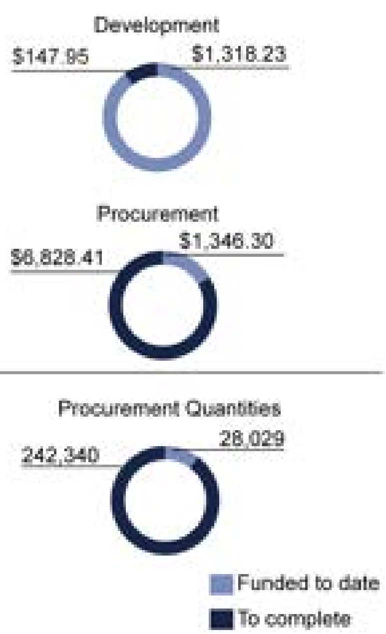
(fiscal year 2018 dollars in millions) (Charts not to scale)



Total quantities comprise 833 development quantities and 270,369 procurement quantities.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)



Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	○	NA
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	NA
• Complete a system-level preliminary design review	○	NA
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	○	NA
• Test a system-level integrated prototype	●	NA
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	NA
• Demonstrate critical processes on a pilot production line	○	NA
• Test a production-representative prototype in its intended environment	●	NA

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

HMS Program

Technology Maturity and Design Stability

The HMS program now plans to acquire the Leader and Manpack radios as non-developmental items, which has precluded the program's use or tracking of any critical technologies.

At the HMS program's development start in 2004, the program did not assess the maturity of its critical technologies—an approach inconsistent with best practices. The program had also not fully matured its critical technologies by its 2011 production start. Instead, the program completed development of individual critical technologies in May 2015. This divergence from best practices likely contributed to the nearly 150 percent increase in development costs since the first full estimate.

At its 2008 critical design review, the program had completed less than half of its planned design drawings, which did not meet best practices criteria for design stability. Most importantly, the program's persistent technology immaturity between 2004 and 2011, including at the critical design review, contributed to radio designs that did not fully accommodate the final form, fit, and function of critical technologies as they matured. These design shortfalls became evident as HMS radios entered testing.

Specifically, in fiscal year 2014, developmental testing of the Manpack radio revealed deficiencies with the system's reliability. Initial operational test and evaluation that same year flagged suitability shortfalls, specifically related to the excessive weight of the Manpack units. Similarly, operational tests of the Rifleman radio in fiscal year 2014 identified suitability problems related to overheating and rapid battery depletion. Program officials stated that the contractor redesigned both radio systems to resolve these various problems, although the Army has not yet completed tests to verify these corrective fixes. Subsequent testing and procurement of the Rifleman radio has been deferred. Further, program test plans do not currently reflect the Army's transition from the one-channel Rifleman radio to the two-channel Leader radio, which will likely require its own operational tests.

Production Readiness

The HMS program has yet to assess its production readiness for the Leader radio, and Manpack radio production readiness remains unassessed nearly 7 years after that radio entered low-rate initial production. According to HMS program officials, the program assessed the production readiness of the Rifleman radio system in May 2011, but the Army will require a new assessment for the Leader radio. Program officials also stated that the HMS program will assess the production readiness of the Manpack radio as part of its separate full rate production decision in February 2021.

Other Program Issues

At present, use of the MUOS waveform—which some Manpack radios will rely on—is largely unavailable to warfighters because DOD has yet to authorize the waveform's use in an operational environment. Although the program has not identified MUOS as a critical technology, without this waveform, affected Manpack radios are able to communicate only through legacy communications capabilities, which limit the capacity of the network of radios.

The Army has completed a network review that will evaluate HMS, as well as other Army communications programs, in an effort to assess processes, reduce system vulnerabilities, redefine capability gaps, and improve needed equipment. According to HMS program officials, this review increased uncertainty about the program's schedule and acquisition strategy. Consequently, while the Leader contract award is now planned for June 2018, the Army has not yet updated the HMS acquisition program baseline to reflect these new plans.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. Program officials stated that the Army's network review concluded that both the Leader radio and Manpack radio are essential to the future of the network. According to the program, the Leader radio test plan is currently in development. As for the Manpack radio, officials noted that it provides two simultaneous channels of secure voice and data communications using MUOS and other advanced networking waveforms and therefore supports legacy communications, as well as new waveform technologies, as required. Officials also said the Manpack radio will help the Army toward its goal of improving communication security and addresses a communications need for Army vehicles. Program officials further stated that a manufacturing readiness assessment was performed for each Manpack radio manufacturer, low-rate production was demonstrated for each vendor, and capability is in place to begin full rate production.

Source: Northrop Grumman

Integrated Air and Missile Defense (IAMD)

The Army's Integrated Air and Missile Defense (IAMD) program is being developed to network sensors, weapons, and a common battle command system across an integrated fire control network to support the engagement of air and missile threats. The IAMD battle command system will provide a capability to control and manage IAMD sensors and weapons, such as the Sentinel radar and Patriot launcher and radar, through an interface module that supplies battle management data and enables networked operations.

Program Essentials

Program office: Redstone Arsenal, AL

Prime contractors: Northrop Grumman Space & Mission Systems Corporation and Raytheon

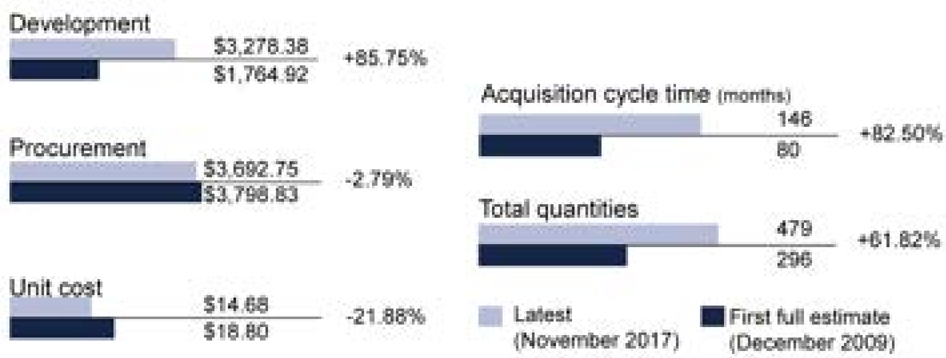
Contract type: Cost-plus-incentive-fee/cost-plus-fixed-fee (development)

Next major milestone: Low-rate initial production (September 2020)

Program Performance

(Charts not to scale)

(fiscal year 2018 dollars in millions)



Total quantities comprise 25 development quantities and 454 procurement quantities.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	○	○
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	NA	NA
• Demonstrate critical processes on a pilot production line	NA	NA
• Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

IAMD Program

Technology Maturity and Design Stability

The IAMD program has demonstrated that all of its critical technologies—integrated battle command, integrated defense design, integrated fire control network, and distributed track management—are fully mature. Almost 6 years after the design review, the program no longer has a stable design, which is reflected as an update to our attainment of product knowledge. While the program had previously completed over 90 percent of its design drawings, the program has made a number of design changes that added almost a thousand new drawings. These changes include, among other things, added functionality and new components to protect against parts obsolescence.

Following limited testing in June 2016, the Army Test and Evaluation Command reported that software deficiencies rendered the IAMD system “not suitable, not survivable, and not reliable.” In February 2017, DOD’s Office of Operational Test and Evaluation further found the system’s software to be “neither mature nor stable.” This poor performance was largely driven by instability of the IAMD battle command system (IBCS) software, which was used in the limited user testing. Since limited user testing was completed, the program has updated the IBCS software, specifically focusing on fixing problems observed during testing, such as increasing the stability and reliability of the software. These updates began in 2016 and a series of test events were executed through October 2017 to verify the fixes. Early results indicate that the software issues experienced during the 2016 limited user testing have been corrected, but officials noted that testing continues.

The program has implemented several changes to reduce risk. The program reports that one of these changes includes requiring the contractor to now test IBCS software with tactical network and weapon/sensor interfaces prior to acceptance. Officials noted they believe this to be a key step to reducing remaining technical risks within the program.

Production Readiness

After the unsatisfactory performance of its limited testing in June 2016, the Army delayed the IAMD low-rate production decision—previously planned for August 2016—to September 2020 in order to allot more time for developmental testing. The program also plans to update its Acquisition Program Baseline (APB) in conjunction with that decision. Additionally, according to program officials, the program plans to conduct a formal manufacturing readiness assessment for the program in preparation for the program’s low-rate production decision, at which time they expect all vendors to be ready for low-rate initial production. The Army now plans to declare initial operational capability in fiscal year 2022, nearly 4 years later than previously planned.

Other Program Issues

The program has experienced development cost growth in excess of limits authorized in its APB. This cost breach resulted from the Army’s decision to request increased program funding in fiscal year 2018 and restructure the program schedule to allot increased time for remaining development and implement corrective fixes following the June 2016 limited test event. Specifically, the Army’s fiscal year 2018 budget request reflected new requirements for Advanced Electronic Protection Enhancements, which the Army believes will develop and assess solutions to the IAMD emerging threats and vulnerabilities to advanced electronic attack. The program plans for IAMD Battle Command System Command and Control and radio frequency data and voice network protection features to be developed and assessed against current and postulated advanced electronic attack systems and techniques. Additionally, they plan to demonstrate and assess electronic protection and emerging threat solutions in live and simulated advanced electronic attack environments. Similarly, the program plans to coordinate electronic protection and advanced threat solutions with joint services and other agencies, such as the Missile Defense Agency.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. In its comments, the program stated that the IAMD design is stable. According to program officials, the original design was demonstrated in a limited user test and has a complete technical data package. The program also said that the original IAMD design later changed at the user’s request, and the data package for the new design is complete, with the exception of four engineering changes that require incorporation. Additionally, the program office stated its view that obsolescence is unavoidable in any program, but is particularly prevalent in a program such as IAMD that heavily utilizes commercial off the shelf components. The program noted that IAMD has a parts obsolescence management program to proactively address obsolescence in a cost-effective manner, and that this helps prevent negative cost and schedule effects to the program.

Source: U.S. Army

Indirect Fire Protection Capability Increment 2-Intercept Block 1 (IFPC Inc 2-I Block 1)

The Army's IFPC Inc 2-I is a follow-on effort to enhance and extend the range of the first IFPC increment, which provided a short-range capability to counter threats from rockets, artillery, and mortars. IFPC Inc 2-I consists of four separate subsystems: an existing sensor; an interceptor; fire control system; and a new multi-mission launcher being developed by the Army. IFPC Inc 2-I consists of three blocks. Block 1 adds the capability to counter cruise missiles and unmanned aircraft. We assessed Inc 2-I Block 1.

Program Essentials

Program office: Huntsville, AL

Prime contractors: Not applicable (U.S. Army Aviation and Missile Research, Development, and Engineering Center and Letterkenny Army Depot are responsible for development and production)

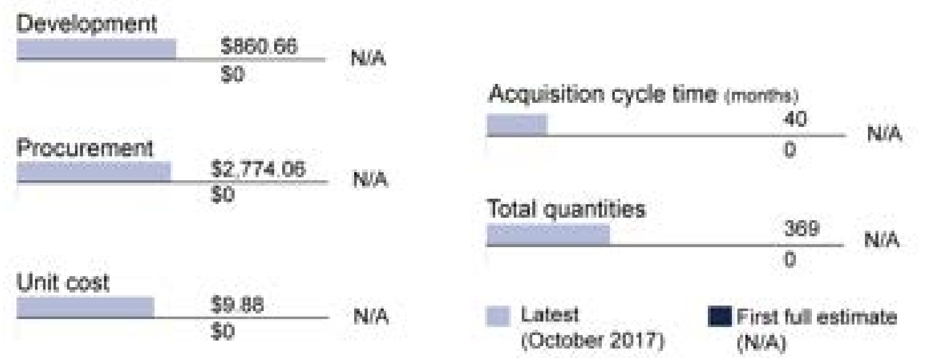
Contract type (planned): Intra-service support agreements

Next major milestone: Start of operational test (August 2019)

Program Performance

(Charts not to scale)

(fiscal year 2018 dollars in millions)



Because IFPC Inc 2-I Block 1 does not have an acquisition program baseline, we have no basis of comparison for program performance. Total quantities comprise 13 development quantities and 356 procurement quantities.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	NA	NA
• Demonstrate all critical technologies in form, fit and function within a realistic environment	NA	NA
• Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	NA	NA
• Test a system-level integrated prototype	○	○
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or that critical processes are in statistical control	NA	NA
• Demonstrate critical processes on a pilot production line	NA	NA
• Test a production-representative prototype	NA	NA

● Knowledge attained, ○Knowledge not attained, – Information not available, NA Not applicable

IFPC Inc 2-I Block 1 Program

Technology Maturity and Design Stability

While the program did not identify any critical technologies prior to entry into system development, officials expressed concern related to the difficulty associated with integrating the four subsystems that comprise Block 1—the Sentinel radar, the AIM-9X interceptor, the Integrated Air and Missile Defense (IAMD) Battle Command System (IBCS), and the multi-mission launcher. Specifically, systems pose potential integration challenges to Block 1 system development because their capabilities will be used in new ways to prosecute different threats.

The Army's IAMD program will produce the IBCS, which is currently designed to control the Patriot missile launcher and radar system. However, the IAMD program has recently identified significant IBCS deficiencies during developmental testing, which IFPC Inc 2-I Block 1 program officials report have caused them to rely on a non-network integrated version of the IBCS for Block 1 system development. According to program officials, the Block 1 system will integrate a later version of IBCS prior to Block 1's initial capability in fiscal year 2021. Although both the IAMD and IFPC programs expect this later version of IBCS to be available in time for IFPC Inc 2-I Block 1 initial operating capability, any additional delays to the IBCS may result in the IFPC Inc 2-I Block 1 system being deployed without the full networked capability of the Integrated Fire Control for which it was designed. Specifically, officials stated that the IFPC Inc 2-I Block 1 program will be unable to take advantage of the Army's IAMD network, resulting in turning the IFPC Inc 2-I Block 1 system from a brigade-level asset to a much smaller, platoon-level asset.

In addition, program officials identified continuing system integration challenges specific to the program's designated interceptor, the AIM-9X missile. These challenges stem, in part, from the IFPC system's ability to enable the interceptor to lock on to a target after launch.

Production Readiness

The Army is developing and producing the Block 1 program's multi-mission launcher at two facilities: the Aviation and Missile Research, Development, and Engineering Center (AMRDEC) and Letterkenny Army Depot (LEAD). According to program officials, AMRDEC and LEAD share responsibilities for developing, fabricating, and assembling the multi-mission launcher units the program will use for developmental testing, whereas LEAD will assemble the low-rate initial production units. Although program officials stated that production remains on schedule, the Army discovered several hardware deficiencies during manufacturing of the first three test prototypes. Program officials said that instances of hydraulic hoses, cabling, and connectors that attach to the multi-mission launcher were not manufactured correctly due to insufficient detail with the engineering drawings. As a result of these hardware deficiencies, and the restructuring of the software development effort, program officials stated that they were unable to achieve all performance objectives in the first three hardware/software integration events conducted as of December 2017; a total of six hardware/software integration events are planned.

Program officials stated they are confident that LEAD has the capability and capacity to assemble up to 60 multi-mission launcher units per year. Program officials stated they continue to be committed to utilizing Army facilities for multi-mission launcher development and production, and have identified both Army and non-Army sources for launcher-related materials when production transitions to LEAD.

Other Program Issues

The Block 1 program is completing development work prior to obtaining approval from the Assistant Secretary of the Army for Acquisition, Logistics, and Technology to formally enter system development. In November 2016, the Army held a Block 1 program review to authorize entry into system development. This review surfaced several programmatic issues that further delayed the program's formal entry into system development. These issues included concern within senior Army leadership about whether the program had built sufficient time into the Block 1 schedule to correct any deficiencies that may arise during testing prior to production start. To mitigate that concern, program officials stated the program added 5 months between Block 1's limited user test and its low-rate initial production decision review (Milestone C). This new schedule delays Block 1's initial operating date from fiscal year 2020 to fiscal year 2021. Further, according to program officials, Army acquisition leadership changes have also delayed Block 1's formal entry into system development. Program officials stated that they have not yet obtained formal approval to enter system development, but that many of the risk reduction activities associated with system development have continued through the use of Army facilities for development and production.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

Source: U.S. Army

Joint Air-to-Ground Missile (JAGM)

The Joint Air-to-Ground Missile is an Army-led program with joint requirements from the Navy and Marine Corps. The missile is designed to be air launched from helicopters and unmanned aircraft systems to target tanks, light armored vehicles, missile launchers, bunkers, and buildings. It is intended to provide precision attack capabilities no matter the time of day or weather conditions. JAGM will replace all Hellfire missile variants.

Program Essentials

Program office: Redstone Arsenal, AL

Prime contractor: Lockheed Martin

Contract type: Fixed-price incentive (development)

Next major milestone: Low-rate production (May 2018)

Program Performance

(Charts not to scale)

(fiscal year 2018 dollars in millions)

Total quantities comprise 118 development quantities and 26,319 procurement quantities.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	○	○
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	●	●
• Test a system-level integrated prototype	●	●
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	NA	NA
• Demonstrate critical processes on a pilot production line	NA	NA
• Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

JAGM Program

Technology Maturity

JAGM has three critical technologies—the guidance seeker assembly/sensor platform, sensor software, and mission software, all of which the program has assessed as mature following two successful test shot events in June 2016. JAGM components, including the motor, warhead, and electronics, are common with the existing Hellfire missile. The Army's decision to include these components in the JAGM design followed a 2010 system-level preliminary design review (PDR) and a 2012 program restructuring, which included extending technology development by more than 2 years to address affordability concerns and risk reduction needs. JAGM did not conduct a second PDR following this restructuring because the program had already conducted a system-level PDR in 2010.

Design Stability

At the January 2016 critical design review (CDR), the program had released over 90 percent of JAGM drawings—performance consistent with our best practices criteria for design stability. Since then, the total number of JAGM drawings has increased slightly, but not to an extent that undermines the program's design stability. The program now expects 199 engineering drawings at program completion and has released 96 percent of these drawings to manufacturing.

Production Readiness

JAGM will be manufactured at the same facility as the Hellfire missile. The program office is tracking 15 different metrics related to hardware and software to assess JAGM's readiness for production. According to program officials, these metrics currently meet expected values, and the program expects all production processes to be mature prior to low-rate initial production.

Nonetheless, the program is monitoring a risk related to consistently producing a circuit card coating material within specifications. Program officials stated that they are addressing this production issue, which affects circuit cards in the missile's guidance section, with the subcontractor and also exploring alternative materials that could be used.

In August 2017, program officials reported a 6-month delay to JAGM's low-rate initial production decision. The program officials reported that this delay stems from a combination of production issues from the JAGM contractor, Lockheed Martin, that have delayed test asset deliveries needed to complete system development. Despite these delays, program officials expect that the initial capability and full-rate production dates outlined in JAGM's revised August 2017 acquisition program baseline remain achievable.

Other Program Issues

The Army has delayed initial operational testing and evaluation (IOT&E) by 2 years because the AH-64 Apache helicopter's current software—used to launch Hellfire missiles—requires more pilot input to access JAGM functionality than expected. New platform software in development will enable pilots to select the full range of options with far less physical interface with the platform. Flight testing of this new software is planned for the fourth quarter of fiscal year 2018 to be followed by IOT&E.

In the interim, the program has plans to conduct a limited user test of 10 missile shots with existing platform software and hardware to demonstrate the missile's capabilities. The Army previously scheduled this limited user test for May 2017, but has since delayed it to January 2018. Program officials stated that they do not expect any material changes to the missile between the limited user test and IOT&E.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office did not have any comments.

Source: U.S. Army

M109A7 Family Of Vehicles (M109A7 FOV)

The Army's M109A7 FOV system consists of two individual vehicles: a self-propelled howitzer (SPH) and a tracked ammunition carrier that provides operational support. The SPH is a tracked, aluminum armored vehicle armed with a 155 millimeter cannon. The M109A7 FOV is expected to provide improved sustainability over the current howitzer fleet through the incorporation of a newly designed hull; modified M2 Bradley infantry fighting vehicle power train, suspension system, and track; and a modernized electrical system.

Program Essentials

Program office: Warren, MI

Prime contractor: BAE Systems Land & Armament L.P.

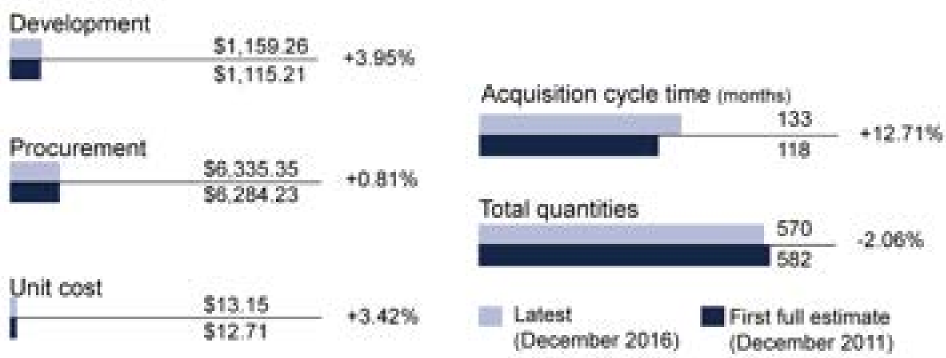
Contract type: Fixed-price incentive (procurement)

Next major milestone: Full-rate decision July 2018

Program Performance

(Charts not to scale)

(fiscal year 2018 dollars in millions)



Total quantities comprise 2 development quantities and 568 procurement quantities.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	…	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	…	●
• Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	…	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	○
• Demonstrate critical processes on a pilot production line	○	○
• Test a production-representative prototype in its intended environment	○	●

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

M109A7 FOV Program

Technology Maturity and Design Stability

The M109A7 FOV program currently has mature critical technologies and a stable design. The program's two critical technologies—power pack integration and the ceramic bearing of the generator assembly—were immature at development start, but assessed as fully mature at the program's October 2013 entry into low-rate initial production. The contractor has released all of the expected drawings for the M109A7 FOV to manufacturing and has demonstrated a system-level integrated prototype. However, discrepancies in the design of the transmission oil cooler might be the cause behind recent engine component failures. These failures, according to the program office, have led to an interim design change to improve the transmission oil cooler's structural robustness. Following additional testing, the contractor plans to develop a final design change, which will be introduced during full-rate production.

Production Readiness

To date, the program has not demonstrated that its manufacturing processes are in statistical control, more than 5 years after production began. The program started low-rate initial production in October 2013, and the Army accepted delivery of the first vehicle in March 2015. To assess production readiness and efficiency gains over time, the program compares totals for expected and actual manufacturing hours. Our best practices work has shown that if a program's critical manufacturing processes are not demonstrated and in control before production begins, it is at risk of increased cost and schedule delays.

Other Program Issues

The program's current schedule is predicated on completing initial operational test and evaluation (IOT&E) with few, if any, new discoveries of technical deficiencies. The program started IOT&E in October 2016, but suspended that testing with less than one-third of the planned missions accomplished primarily due to failures in the legacy gun components and reliability issues. According to program officials, these failures will not be addressed until follow-on developmental work is completed. The major technical risk for the program is that it may fall short of its reliability requirements due to the use of these legacy components. Since the program was unable to complete the scheduled IOT&E, a second IOT&E event has been scheduled to start and complete in March 2018—a delay of approximately 16 months. To prepare for this testing, the program has made several changes to the vehicle including upgrading breech components, system software, and manuals and training, along with minor hardware changes to improve reliability. The Army will evaluate the effectiveness of these changes during IOT&E. If the changes prove effective, the program does not expect to exceed its cost threshold. However, previously established program dates, such as initial capability, have already been breached. In the event that remaining testing identifies new deficiencies and the need for additional design changes and retrofitting, the program will likely incur cost growth and further schedule delays.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

Source: U.S. Army

Patriot Advanced Capability-3 Missile Segment Enhancement (PAC-3 MSE)

The Army's PAC-3 MSE is a surface-to-air missile designed to defeat tactical ballistic missiles and other aerial threats. The MSE is the latest version of PAC-3 missiles integrated into the PATRIOT system, which includes radars, launchers, and a command and control system. The PAC-3 MSE improves upon earlier PAC-3 variants and provides a more lethal interceptor with expanded range and accuracy against complex threats.

Program Essentials

Program office: Redstone Arsenal, AL

Prime contractor: Lockheed Martin

Contract type: Fixed-price incentive (low-rate initial production)

Next major milestone: Full-rate production (April 2018)

Program Performance

(Charts not to scale)

(fiscal year 2018 dollars in millions)

We could not calculate a change in acquisition cycle time as the program's first full estimate did not identify an initial operational capability date.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	○	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	○	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	●
• Demonstrate critical processes on a pilot production line	●	●
• Test a production-representative prototype in its intended environment	●	●

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

PAC-3 MSE Program

Technology Maturity, Design Stability, and Production Readiness

The PAC-3 MSE program currently has mature critical technologies, a stable design, and production processes that are in statistical control.

Although the PAC-3 MSE has components that are 90 percent common with an earlier PAC-3 variant, four unique technologies had to be developed: a dual pulse solid rocket motor; thermal batteries; an ignition safety device; and insensitive munitions to prevent inadvertent launch or detonation. None of these technologies were mature at the program's development start—an approach inconsistent with best practices.

PAC-3 MSE began production in March 2014 by demonstrating that all materials, manpower, tooling, and facilities were proven on a pilot production line and were available to meet the low rate production schedule, as recommended by DOD guidance. However, this demonstration did not occur until over 2 years after production start, which is inconsistent with acquisition best practices. According to best practices, programs should demonstrate manufacturing processes to be in statistical control—that is, repeatable, sustainable, and consistently producing parts within the quality standards—prior to production start.

In November 2016, the program assessed its readiness for full-rate production and concluded that contractors would be sufficiently prepared after addressing identified risks, such as issues related to the uniform production of the solid rocket motor. Program officials said progress has been made on these risks and all PAC-3 MSE contractors will have mature processes to support the full-rate production of 20 PAC-3 MSE missiles per month by early 2018.

Other Program Issues

The PAC-3 MSE program achieved initial operational capability in July 2016—about 5 months ahead of schedule—by equipping a PATRIOT battalion with 48 missiles. Program officials attributed the early completion of this milestone to faster-than-expected missile deliveries from the prime contractor and synergies with existing training for PATRIOT battalions.

In November 2017, the program concluded operational testing following a 2-month delay. The delay occurred because there was a target malfunction during a June 2017 flight test requiring testing to be rescheduled. As a result, the program delayed the PAC-3 MSE full rate production decision to April 2018. The program acquisition baseline schedule states that the full rate production decision is to occur by the end of June 2018.

Program officials stated that the program's ability to meet cost goals depends on whether or not it can procure steady quantities of PAC-3 MSE and related variant missiles for the United States and foreign countries. For fiscal years 2018 through 2022, the Army and program office project about $49.3 million in savings (in fiscal year 2015 dollars), assuming that DOD receives foreign military sales orders for about 100 missiles each year. Decreases in quantities of U.S. or foreign purchases of PAC-3 MSE or its earlier variant would prevent the program from meeting target production rates and prices, according to officials.

The PAC-3 MSE program continues to encounter delays in definitizing contract actions for production. Program officials said that they used undefinitized contract actions—actions that authorize contractors to begin work and incur costs prior to reaching final agreement on contract terms, specifications, and price—to award annual production contracts for fiscal years 2014 thru 2017 because negotiations for a definitive contract would have precluded production efficiencies and resulted in delays to fielding PAC-3 MSE missiles. We previously reported delays in definitizing undefinitized contract actions place the program at risk of cost growth in part because the government may incur unnecessary costs if requirements change before the contract is definitized. The program took 2 years to definitize pricing and terms for the fiscal year 2014 contract. Officials report that definitization of the pricing and terms for the following 3 fiscal years is now complete or nearly complete. Officials also report that they completed negotiations on pricing for fiscal year 2018 production in December 2017, thereby avoiding the use of an undefinitized contract action for the fiscal year 2018 quantities.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

In commenting on a draft of this assessment, program officials noted that the program held two production readiness assessments. According to the program, the first of these two assessments was completed in August 2013 prior to the low-rate initial production decision, and the second assessment was completed in January 2017 prior to the system verification review. Officials further stated that the program has worked to develop and test critical technologies and to mitigate all associated risks.

Improved Turbine Engine Program (ITEP)

The Army's ITEP is developing a replacement engine for the Black Hawk and Apache helicopter fleets. The new engine is designed for increased power, performance, and fuel efficiency; enhanced reliability; increased service life; and a lower maintenance burden. The Army plans to begin fielding these engines in fiscal year 2026.

Source: U.S. Army

Program Essentials

Program office: Redstone Arsenal, AL

Prime contractor(s): Advanced Turbine Engine Corporation and General Electric Company

Contract types: Fixed-price incentive firm target (technology maturation and risk reduction)

Cost-plus-incentive-fee (development; planned)

Next major milestone: Development start (December 2018)

Estimated Program Cost

(FY 2018 dollars in millions)

Planned Quantities

Current Status

ITEP entered the technology maturation and risk reduction phase in August 2016 with the Army's award of two fixed-price incentive (firm target) contracts to General Electric Company and Advanced Turbine Engine Corporation. Each contractor will hold a separate preliminary design review with the Army in February and March 2018 to establish an allocated baseline for the engine that will define all ITEP subsystems and how they are to work together.

In November 2017, the Acting Assistant Secretary of the Army for Acquisition, Logistics and Technology approved the solicitation of contract proposals for ITEP development. The Army intends to award a cost-plus-incentive-fee contract for system development to one of the two contractors that are developing preliminary designs. Currently, the program schedule provides for an acquisition cycle time of approximately 11 years.

The program's three critical technologies—advanced inlet particle separator, compressor/advanced aerodynamics, and hybrid bearings—were identified as approaching maturity during a preliminary technology readiness assessment in October 2014. Consistent with DOD policy, the Army plans to complete a technology readiness assessment in June 2018, prior to the program's December 2018 development start.

Since 2015, Sikorsky Aircraft Corporation and Boeing, the manufacturers of the Black Hawk and Apache helicopters, have conducted analyses in support of integrating ITEP hardware, electrical systems, and software into the helicopter airframes. These efforts, designed to identify integration risks and facilitate development of mitigation strategies, will be conducted in parallel with ITEP's preliminary design review.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office did not have any comments.

Source: U. S. Army

Long Range Precision Fires (LRPF)

The Army's Long Range Precision Fires (LRPF) will be part of a family of ballistic missiles designed to attack area and point targets to planned ranges of at least 300 kilometers. Each LRPF launch pod missile container is planned to hold one to four missiles. LRPF will be compatible with existing M142 and M270 rocket launch systems. LRPF is intended to replace the Army Tactical Missile System (ATACMS) and comply with statutory requirements for insensitive munitions and DOD policy on cluster munitions.

Program Essentials

Program office: Redstone Arsenal, AL

Prime contractors: Advanced Technology International, Lockheed Martin, and Raytheon

Contract types: Various cost-reimbursement types (technology maturation and risk reduction)

Next major milestone: Development start (January 2021)

Estimated Program Cost

(fiscal year 2018 dollars in millions)

Planned Quantities

Current Status

LRPF entered technology development in March 2017, with the start of system development scheduled for 2021. The Army continues to refine its planned performance requirements for the system, and program officials stated that they expect these requirements to be approved in mid-2018.

According to program officials, they continue to evaluate two requirements—LRPF range and lethality. The program officials stated that, in fiscal year 2017, the Army proposed an increase to the planned range requirement—from 300 to 400 kilometers—and considered an increase in the planned minimum number of missiles per launch container from one to two, with no change to the planned maximum of four. LRPF contractors subsequently conducted trade studies that found that the desired range and lethality could be met with two missiles per launch container.

Under its technology maturation and risk reduction contracts, the Army plans to competitively prototype the LRPF system ahead of a planned "down-select" to a single contractor for system development. According to the program office, it has contracted for four prototypes each from Lockheed Martin and Raytheon. The Army plans to conduct a preliminary design review in November 2018. Following the review, both contractors will conduct three flight tests each between July and December 2019. The Army plans to use the results of these tests and the preliminary design review to inform its source selection for system development.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The office stated the program is meeting its cost and schedule targets and has completed systems engineering reviews with LRPF contractors. Further, the office said that the Army is considering program acceleration, but noted that would likely affect LRPF budget estimates.

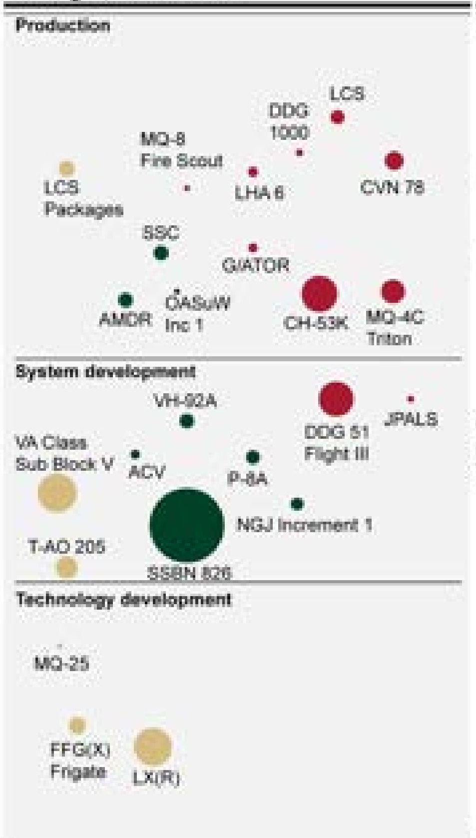
Navy and Marine Corps Program Assessments

We completed individual assessments on 24 of the Navy's 44 current and future major defense acquisition programs. Of these 24 programs, 21 are in either system development or early production while 3 are future programs that DOD expects to enter system development in the next few years. We found the Navy currently estimates a need of $252 billion to complete the acquisition of these 24 programs. We also compared these programs' first full estimates of cost and schedule with their current estimates and found that:

- net cost growth totals $135.8 billion, the majority of which occurred more than 5 years ago, and
- program schedule delays average approximately 32 months.

Three of the 24 programs—LHA 6, LCS, and T-AO 205—completed all activities associated with the applicable knowledge-based best practices we assess, although only LHA 6 fully completed these activities at the time the knowledge points were reached.

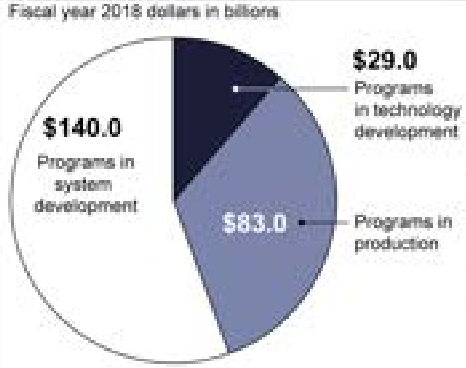
Acquisition Phase and Size of the 24 Programs Assessed



Note: Bubble size is based on each program's currently estimated future funding needed.

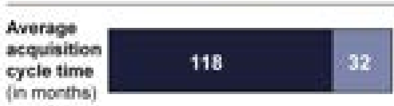
Currently Estimated Acquisition Costs for the 24 Programs Assessed

Fiscal year 2018 dollars in billions



Cost and Schedule Growth on 19 Programs in the Current Portfolio

Fiscal year 2018 dollars in billions



Note: In addition to research and development and procurement costs, total acquisition cost includes acquisition-related operation and maintenance and system-specific military construction costs.

Summary of Knowledge Attained to Date for Programs Beyond System Development Start

Program common name	Knowledge Point (KP) 1 Resources and requirements match: At KP1	Knowledge Point (KP) 1: Current Status	Knowledge Point 2 Product design is stable: At KP2	Knowledge Point 2: Current Status	Knowledge Point 3 Manufacturing processes are mature: At KP3	Knowledge Point 3: Current Status
ACV	○	●	○	○	KP 3 in future	
AMDR	○	○	○	●	○	○
CH-53K	○	●	○	●	○	○
CVN 78	○	○	○	●	N/A	
DDG 1000	○	○	○	●	N/A	
G/ATOR	○	●	○	●	○	○
JPALS	○	○	○	●	KP 3 in future	
LHA 6	●	●	●	●	N/A	
LCS	○	●	○	●	N/A	
LCS Packages	○	○	○	●	N/A	
MQ-4C Triton	○	●	○	●	○	○
MQ-8 Fire Scout	○	- - -	○	●	- - -	- - -
NGJ Inc1	○	○	○	○	KP 3 in future	
OASuW Inc 1	○	●	○	●	○	○
SSBN 826	○	○	KP 2 in future		N/A	
SSC	●	●	○	●	○	○
T-AO 205	○	●	KP 2 in future		N/A	
VH-92A	○	●	○	○	KP 3 in future	

● All applicable knowledge practices completed
○ One or more applicable knowledge practices were not completed
N/A Knowledge practice is not applicable
- - - Information not available for all applicable knowledge practices

Source: GAO analysis of DOD data. | GAO-18-360SP

Navy and Marine Corps Program Assessments

Source: U.S. Marine Corps.

Amphibious Combat Vehicle (ACV)

The Marine Corps' ACV is the successor program to the canceled Expeditionary Fighting Vehicle (EFV). The ACV is intended to transport Marines from ship to shore and provide them with improved mobility and high levels of protection. The ACV acquisition approach calls for three increments of development (1.1, 1.2, and 2.0) and leverages work accomplished under the EFV program. We assessed ACV increment 1.1.

Program Essentials

Program office: Stafford, VA

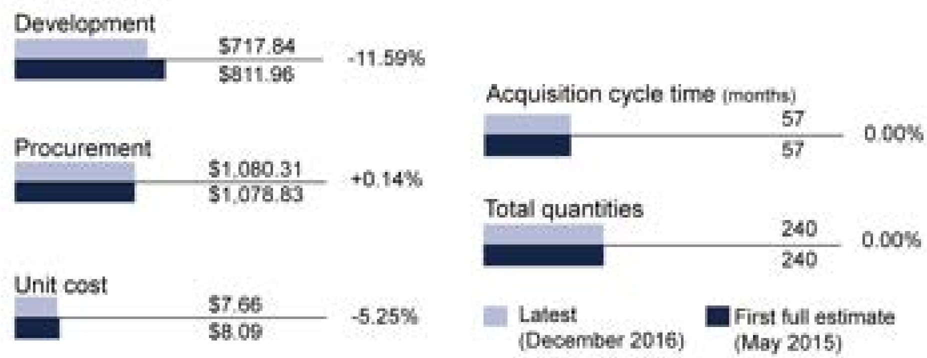
Prime contractors: BAE Systems and Science Applications International Corporation

Contract type: Fixed-price incentive/firm-fixed-price/cost-plus-fixed-fee (development)

Next major milestone: Low-rate initial production (June 2018)

Program Performance

(fiscal year 2018 dollars in millions) (Charts not to scale)



Total quantities comprise 36 development quantities and 204 procurement quantities.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	●	●
• Test a system-level integrated prototype	○	○
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	NA	NA
• Demonstrate critical processes on a pilot production line	NA	NA
• Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

ACV 1.1 Program

Technology Maturity

The ACV's two critical technologies, the Driver Vision Enhancement (DVE) system and the Remote Weapon Station (RWS), entered development as mature technologies. The DVE system operates on a legacy system the ACV is replacing the Assault Amphibious Vehicle. The RWS is based on a system that is also used on a different platform and has undergone successful testing for water suitability. According to Department of Defense testing officials, ACV contractors have integrated both government-furnished technologies in ACV prototypes as part of developmental testing.

Design Stability

The Marine Corps awarded two separate contracts to competing vendors for the development phase of the ACV 1.1. Under these contracts, the vendors were to design and produce 16 ACV prototype vehicles each for testing and evaluation. Contractors delivered all 32 prototypes by November 2017.

The ACV 1.1 program completed at least 90 percent of expected drawings at the time of the system-level critical design review in July 2016. As of October 2017, the program office reported that it has now completed 100 percent of the expected design drawings, indicating that the design is stable.

DOD began developmental testing of the prototypes in March 2017. The first round of developmental testing ended with a corrective action period to incorporate any potential design changes identified during the course of testing. The prototypes will undergo three rounds of developmental testing and corrective action periods through the end of the development phase and into production. Live fire testing to support capabilities such as force protection and system survivability started in June 2017. The Marine Corps has scheduled an operational assessment from January through March 2018 to inform the program about a number of areas that includes satisfying ACV capability requirements and readiness to proceed into low-rate initial production.

Production Readiness

The program will make two critical decisions in 2018: the first is to choose a single vendor for the production contract, and the second is to determine if the program is ready start low-rate initial production. The decision to enter low-rate production is scheduled for June 2018.

The Marine Corps started a production readiness review in November 2017 to determine if contractors' production maturity was sufficient for starting low-rate production after the production decision. In December 2017, the program sent solicitations to the two participating contractors to obtain their proposals for low- and full-rate production, with each reflecting updated information about test performance and design modifications through November 2017. The competing contractors, which, according to program officials, previously submitted pricing for production vehicles in their original proposals for the development contracts, are able to adjust the price of the ACVs in their proposals for the production contract, based on design changes and other changes realized through development. The proposals were due to the program office in January 2018. The Marine Corps plans to consider the results of the prototype performance tests and the proposed prices when selecting a final contractor for production.

Other Program Issues

The program has adopted some best practices to minimize acquisition risk, such as using mature technologies and fostering competition. However, the Marine Corps is employing an aggressive schedule to obtain initial operational capability (IOC) by fiscal year 2020. The program is scheduled to continue developmental testing more than a year into the production phase, raising the risk that concurrent developmental testing and production could result in costly retrofits and schedule delays. The concurrency risk increased in 2016 when the start date for development testing was delayed and test events were pushed back 2 to 12 months as a result of a stop-work order that was issued to the contractors after a bid protest was filed. For example, the program had to push back a number of scheduled developmental tests by three months while hot weather testing was rescheduled one year later. The Marine Corps moved back the production decision by 4 months, but maintained an August 2020 date for IOC.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office also stated that although it maintains an aggressive schedule, it has met its schedule benchmarks to date and is on track for a low-rate initial production decision in June 2018. According to the program, all key requirements have been proven to be achievable through developmental testing, and the ACV 1.1 operational assessment that is underway has identified no significant issues to date.

The program said the concurrency risk we reported is low and unlikely to result in costly retrofits. It also stated that it had mitigated concurrency risk by conducting developmental testing at extreme temperatures. According to the program, preliminary results of these developmental tests indicate that no significant redesign efforts will be required.

Source: © 2015 Raytheon Company

Air and Missile Defense Radar (AMDR)

The Navy's AMDR is a next-generation radar program supporting surface warfare and integrated air and missile defense. AMDR is developing a radar—known as AN/SPY-6(V)1— that is expected to have increased sensitivity for long-range detection to improve ballistic missile defense against advanced threats. The program is also developing a radar suite controller that will interface with an upgraded Aegis combat system to provide integrated air and missile defense for DDG 51 Flight III destroyers.

Program Essentials

Program office: Washington Navy Yard, DC

Prime contractor: Raytheon

Contract type: Cost-plus-incentive-fee (development)

Fixed-price-incentive (production)

Next major milestone: Delivery of first production radar (December 2019)

Program Performance

(Charts not to scale)

(fiscal year 2018 dollars in millions)

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete system-level preliminary design review	○	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	○	●
• Test a system-level integrated prototype	●	●
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	○
• Demonstrate critical processes on a pilot production line	NA	NA
• Test a production-representative prototype in its intended environment	○	○

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

AMDR Program

Technology Maturity

The program assessed AMDR's four critical technologies as mature. Although the program has continued to further demonstrate the AN/SPY-6(V)1 system’s performance and capabilities, as indicated by our attainment of production knowledge section, we believe that the program cannot demonstrate the full maturity of critical technologies until they are tested in their realistic, at-sea environment.

As part of radar development, the contractor built a full-scale, single-face radar array, which the Navy has used extensively for developmental testing. This production-representative array is undergoing live ballistic missile defense and anti-air and anti-surface warfare testing through mid-2018 at the Navy's Pacific Missile Range Facility. In April 2019, the Navy plans to integrate the array and an initial version of the Aegis combat system—which integrates ship sensors and weapon systems to engage threats—planned for DDG 51 Flight III at a land-based test site to support further testing. However, the Navy will not test the full integrated radar and Aegis combat system until both are installed on the lead ship, sometime in 2022.

In spring 2017, AMDR completed software development to support core AN/SPY-6(V)1 capabilities prior to entering production. Remaining software development includes software updates—occurring through 2020—that are intended to enhance radar defense capabilities and integrate the radar with the combat system.

Design Stability and Production Readiness

AMDR entered low-rate initial production for three AN/SPY-6(V)1 radars in May 2017—4 months ahead of schedule—with core system hardware and software complete, a stable design, and production capabilities that meet DOD guidelines, but which fall short of industry best practices. Program officials stated AMDR also realized an overall reduction in procurement cost from the original independent cost estimate due to a better understanding of ownership, production, and material costs realized during development.

The AMDR program office plans to procure more than two-thirds of the total radars prior to operational testing completion. The Navy deliberately planned for AMDR to begin production prior to the start of Aegis upgrade software development, a prerequisite for operational testing, to allow time for key radar technologies to mature and for the design to stabilize, minimizing the risk of beginning combat system development with insufficient radar knowledge. However, the concurrency between AMDR’s schedule for Aegis combat system integration, land- and sea-based testing, and production dictates that the Navy will need to address any deficiencies yet to be identified for radar integration with the Aegis upgrade after production is underway or complete for many of the radars. Any retrofitting needed to address these deficiencies could increase costs.

Other Program Issues

AMDR entered production without an approved Test and Evaluation Master Plan. DOD’s Director, Operational Test and Evaluation (DOT&E) has expressed concern for several years that the Navy’s proposed test approach cannot provide for realistic operational conditions without including the use of an unmanned self-defense test ship equipped with AN/SPY-6(V)1 and Aegis. In 2016, the Deputy Secretary of Defense directed the Navy to include funding for such a test ship in its budget planning. However, in December 2017, program officials stated that the Navy does not plan to request funds for the test ship. Instead, the Navy expects to complete initial operational test and evaluation for DDG 51 Flight III, AN/SPY-6(V)1, and Aegis upgrade through a segmented test approach that includes land-based tests, tests on a manned Flight III ship, and models and simulation. DOT&E reaffirmed to us in late 2017 that for initial operational test and evaluation, the only way to adequately demonstrate the required self-defense capability for Flight III is to test AN/SPY-6(V)1 and Aegis aboard an unmanned test ship.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office also stated that AMDR is executing on schedule, within budget, and remains on schedule for delivery to the DDG 51 Flight III program. It also said that the current developmental test phase, which began at Pacific Missile Range Facility in August 2016, included live testing to demonstrate surface warfare and integrated air and missile defense capabilities. According to the program office, the combat systems integration test event completed in May 2017 led to lessons learned for both the radar and combat system that will enable improvements in interfaces. The program office also said that modeling indicates the ability to support the needs of the Aegis operational requirements for Flight III.

Additionally, the program office reiterated its position that the required self-defense capability for Flight lll can be demonstrated without the use of a AN/SPY-6(V)1 and Aegis equipped unmanned test ship through a combination of land- and sea-based testing on the first Flight III ship and simulation of previous test data.

CH-53K Heavy Lift Replacement Helicopter (CH-53K)

The Marine Corps' CH-53K heavy-lift helicopter is intended to transport armored vehicles, equipment, and personnel to support operations deep inland from a sea-based center of operations. The CH-53K is expected to replace the legacy CH-53E helicopter and provide increased range and payload, survivability and force protection, reliability and maintainability, and coordination with other assets, while reducing total ownership costs.

Program Essentials

Program office: Patuxent River, MD

Prime contractor: Sikorsky Aircraft

Contract types: Cost-plus-incentive-fee (development)
Firm-fixed-price/cost-plus-fixed-fee (engine development)
Fixed-price-incentive/cost-plus-fixed-fee/firm-fixed-price (low-rate initial production)

Next major milestone: Complete operational testing (December 2019)

Program Performance

(fiscal year 2018 dollars in millions) (Charts not to scale)

Total quantities comprise 6 development quantities and 194 procurement quantities.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	○	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	○	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	○
• Demonstrate critical processes on a pilot production line	●	●
• Test a production-representative prototype in its intended environment	●	●

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

CH-53K Program

Technology Maturity, Design Stability, and Production Readiness

The CH-53K program entered production in March 2017 with mature critical technologies and a stable design, but with undemonstrated production processes. Eight months later, production uncertainty persists as the program has yet to bring production processes into statistical control.

The program office has identified two critical technologies—main rotor blade and main gear box. According to program officials, these two critical technologies matured within the last year. The program began flight testing both of the technologies in October 2015. Persistent problems with the main gear box have required the program to delay the planned completion of system-level demonstration tests by 4 months—now scheduled to be completed in May 2019. We previously found that components within the rear module assembly, part of the main gear box, required a number of redesigns. Program officials reported that since the latest redesign, the program has successfully tested the main gear box.

At critical design review, the program assessed what was later proven to be an unstable design. In our 2017 assessment, we reported that the extent of this instability was unknown as the program no longer tracked information on design drawings. For our current assessment, however, the program provided new information indicating that the contractor had released 89 percent of current drawings to manufacturing by the critical design review—a level that falls just short of meeting best practices criteria for design stability. This information also indicated that the contractor had completed nearly 99 percent of CH-53K drawings as of October 2017—a level that reflects design stability.

In August 2017, the program modified the contract that included long lead items to procure two low-rate initial production aircraft. Prior to the production contract award, manufacturing processes were demonstrated on a pilot production line. In addition, the program completed an operational assessment in September 2016, the results of which the Office of the Director of Operational Test and Evaluation (DOT&E) evaluated and determined supported the program's entry into production. The assessment identified the CH-53K engines as a risk area in the program, noting that they may overheat in certain conditions. DOT&E recommended that the program modify aspects of the engine design to fix this issue.

Other Program Issues

The CH-53K contractor plans to move its final assembly line from its current location in West Palm Beach, Florida, to Sikorsky's headquarters in Stratford, Connecticut. The move will require a number of equipment and configuration changes to Sikorsky's Stratford facility, which will take time to complete and pose risk to the CH-53K production schedule. The contractor plans to produce the first four system demonstration test helicopters in Florida before transitioning production to Connecticut in summer 2018 for the fifth, and final, demonstration helicopter. Program officials stated that they expect delivery of the first three helicopters in the second quarter of fiscal year 2018, but that production of the fourth helicopter has been delayed to December 2018 due to a parts shortage.

Program officials also stated that they face challenges related to cybersecurity requirements applicable to the CH-53K system. They stated the challenges include lengthy contractual lead times to field solutions that address continuously evolving cyber threats. They added that this has resulted in prolonged operational risk. At the same time, the program office is planning to award a contract for Sikorsky to identify cybersecurity risks that may exist within the CH-53K system. Once that work is completed, the program office anticipates awarding another contract in order to mitigate any risks discovered. The program office plans to have a related risk mitigation plan completed by the start of initial operational and test evaluation in July 2019.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. Technical comments were incorporated where appropriate. The program office concurred with the contents of this assessment.

Source: U.S. Navy.

CVN 78 Gerald R. Ford Class Nuclear Aircraft Carrier (CVM 78 Class)

The Navy developed the Ford-class nuclear-powered aircraft carrier to introduce new propulsion, aircraft launch and recovery, and survivability capabilities to the carrier fleet. The Ford-class, also known as the CVN 78 class, is the successor to the Nimitz-class aircraft carrier, and its new technologies are intended to create operational efficiencies while enabling a 25 percent increase in operational aircraft flights as compared to legacy carriers. The Navy also expects the new technologies to enable Ford-class carriers to operate with reduced manpower.

Program Essentials

Program office: Washington, DC

Prime contractor: Huntington Ingalls Industries

Contract types: Cost-plus-incentive-fee/cost-plus-award-fee/cost-plus-fixed-fee (CVN 78 detail design and construction)
Cost-plus-fixed-fee/cost-plus-incentive-fee (CVN 79 construction preparation)
Cost-plus-fixed-fee/fixed-price incentive (CVN 79 detail design and construction)

Next major milestone: Initial capability (April 2019)

Program Performance

(fiscal year 2018, dollars in millions) (Charts not to scale)

Total procurement decreases are the result of lower estimated costs for the third ship (CVN 80), which still is not validated by an independent cost estimate.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	○	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	○	●
Product design is stable	**Fabrication Start**	
• Complete basic and functional design to include 100 percent of 3D product modeling	○	●

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

CVN 78 Class Program

Technology, Design, and Production Maturity

In May 2017, the Navy accepted delivery of the lead ship in the Ford class (CVN 78), despite the carrier's reliance on immature technologies and struggle to demonstrate the reliability of mature systems. CVN 78 began construction with immature technologies and an incomplete design, leading to cost and schedule growth. The ship delivered 20 months later than the Navy planned, with construction-related work still remaining and over 40 serious deficiencies that could impact ship operation or safety. As of January 2018, the Navy reported 11 of the program's 13 critical technologies are mature. Shipboard testing continues for several critical systems, including the advanced weapons elevators, electromagnetic aircraft launch system (EMALS), advanced arresting gear (AAG), and dual band radar (DBR). The elevators, AAG, and DBR are struggling to meet reliability targets the Navy uses in assessing ship performance. If these systems cannot show reliability, CVN 78 may not demonstrate it can rapidly launch and recover aircraft—a key requirement for the new class of carriers. The Navy reported EMALS is now meeting reliability targets; however, the Director, Operational Test and Evaluation, raised concerns because the Navy lowered the EMALS reliability target. This lower target will also prevent the ship from meeting the program's aircraft launch and recovery requirement.

Until the Navy fully matures the CVN 78 class critical technologies, the form of these technologies and how they fit on the ship could evolve. Such changes, which are typical outcomes of technology development, could introduce the need for additional design changes to CVN 78 class ships. Despite this, construction continues on the second ship, CVN 79, which is 34 percent complete and the Navy will soon review proposals for the third ship, CVN 80. CVN 79 uses the CVN 78 design with some modifications—that the Navy considers complete—most notably, replacement of DBR with the Enterprise Air Surveillance Radar (EASR), which is still in development and completed its critical design review in August 2017. The Navy does not identify this new system as a critical technology in the Ford Class because it derives from the pre-existing Air and Missile Defense Radar. The Navy plans to procure two EASR units for CVNs 79 and 80 and install the CVN 79 unit during that ship's second phase of delivery. The Navy expects to receive and review shipbuilder proposals for CVN 80 in early 2018. The shipbuilder is already procuring materials for the third ship under the advance procurement contract the Navy reported it awarded in May 2016.

Other Program Issues

In 2007, Congress established a procurement cost cap of $10.5 billion for CVN 78, but lead ship procurement costs have since increased by 23 percent to the current cost cap of $12.9 billion. The National Defense Authorization Act (NDAA) for Fiscal Year 2016 reduced the cap for follow-on ships, including CVN 79 to $11.4 billion, although costs for this ship may also increase. In a prior report, we found that the funds the Navy budgeted for CVN 79 are likely to be insufficient to complete ship construction. Previously, the Navy expressed confidence that CVN 79 would deliver within its cost cap, which assumes unprecedented construction efficiency—namely that CVN 79 production hours will be over 18 percent lower than CVN 78. However, recent construction performance reporting shows the shipbuilder is not meeting this goal. If the shipbuilder cannot achieve its predicted efficiency gain, CVN 79 is at risk of exceeding its current $11.4 billion cost cap. The NDAA for Fiscal Year 2018 raises the cost cap for ships that follow CVN 79 to $12.6 billion.

The NDAA for Fiscal Year 2018 also provides the Secretary of Defense with another way to waive a fiscal year 2016 NDAA limitation on funding for CVN 79 that would not require a certification that the full ship shock trial be completed on CVN 78. The Navy originally planned to defer this test until after CVN 78's initial deployment. In a prior report, we raised concerns about the Navy's plan to delay this trial because such tests can identify potential mission-critical failures before the ship is in an active combat environment. In 2015, the Deputy Secretary of Defense for Acquisition ordered the Navy to conduct the trial before the first deployment.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. In addition, the program office stated that CVN 78 delivered in late May 2017, though with deficiencies, after completing trials. According to the program office, correction of these deficiencies is ahead of schedule. The ship has performed well at sea through January 2018, according the the program, completing hundreds of aircraft launches and recoveries using EMALS and AAG, supported by DBR. This activity contributes to required reliability metrics for these systems.

The program office also stated that CVN 79 construction cost performance remains below the level needed to achieve the planned reduction in production hours from CVN 78, but is improving. The program expects shipbuilder performance to remain stable as it continues to work through the residual effects of shortages in some construction materials, which contributed to its earlier cost performance issues. According to the program office, the Navy plans to deliver a complete and deployable ship on schedule in September 2024, within its cost cap and on a timeline that maintains an 11-carrier force structure.

Source: U.S. Navy

DDG 1000 Zumwalt Class Destroyer (DDG 1000)

The DDG 1000 destroyer is a multi-mission surface ship initially designed to provide advanced capability in the littorals and land-attack to support forces ashore. DDG 1000 class ships feature a stealth design, integrated power system, and total ship computing environment. The Navy adopted a phased acquisition strategy, which separates delivery and acceptance of hull, mechanical, and electrical (HM&E) systems from combat system activation and testing. The Navy accepted delivery of the lead ship's HM&E in May 2016 and combat system activation and testing is underway.

Program Essentials

Program office: Washington, DC

Prime contractors: General Dynamics Bath Iron Works; BAE Systems; Huntington Ingalls Industries; Raytheon

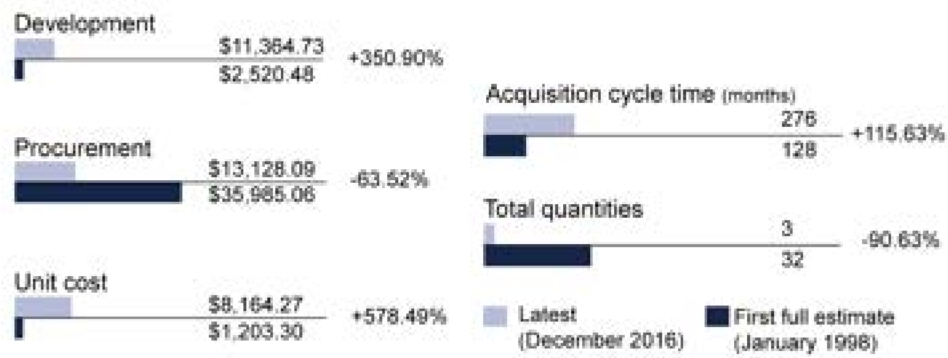
Contract types: Fixed-price incentive/firm-fixed-price/cost-plus-fixed-fee (ship construction); Fixed-price incentive/cost-plus-fixed-fee (advanced gun systems equipment); Cost-plus-fixed-fee/cost-plus-award-fee (mission systems equipment)

Next major milestone: Initial operational test and evaluation (November 2019)

Program Performance

(Charts not to scale)

(fiscal year 2018, dollars in millions)



Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	○	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	●	●
Product design is stable	**Fabrication Start**	
• Complete basic and functional design to include 100 percent of 3D product modeling	○	●

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

DDG 1000 Program

Technology Maturity and Design Stability

Several DDG 1000 critical technologies continue to approach maturity, although the program reports it has released 100 percent of its basic and functional design work, which the program office considers a stable design. As the program continues to mature each technology into a final form, fit, and function, the program may need to revise its basic and functional design to accommodate necessary changes, which could compromise the program's design stability.

To date the Navy has fully matured 5 of 12 critical technologies with plans to demonstrate most of the remaining technologies during post-delivery availability and combat systems activation. In November 2016, program officials reported that the Navy canceled its planned acquisition of the long-range land-attack projectile—a critical technology—due to the munition's high cost per round. DDG 1000 destroyers planned to rely on these munitions for precision fires and offensive operations. The Navy evaluated 5 other munition options but none could meet DDG 1000's requirements. Consequently, the Navy has decided not to pursue a replacement munition, guided or unguided, in the near term—effectively rendering the gun systems useless for combat operations in the foreseeable future.

The planned date for completion of software development for the class has slipped to September 2018, a 9-month slip since last year, due to delays in starting combat system activation trials. These trials will mark the first time that DDG 1000's total ship computing environment, including software, is integrated with system-representative hardware.

The DDG 1000 design was not stable at lead ship fabrication start in 2009—an approach inconsistent with best practices—although the Navy and its shipbuilders reported otherwise at the time. Ongoing development and shipboard testing of technologies have resulted in design changes that have led to significant schedule delays and cost increases.

Production Readiness

The HM&E systems for all three ships of the class have been delivered or are approaching completion. Delivery of the lead ship's HM&E was 18 months behind schedule due in part to challenges completing electrical work associated with the lead ship's power system, a critical technology which provides energy to DDG 1000's propulsion and combat systems simultaneously.

When the lead ship's HM&E was delivered in May 2016, the Navy identified over 320 serious deficiencies that could impact ship operation or safety. Program officials noted the lead ship will not complete final contract trials, foregoing an opportunity to identify and mitigate technical and design deficiencies prior to completing construction of the remaining two ships. As of October 2017, the two remaining ships in the class were 97 and 67 percent complete, with HM&E delivery expected in March 2018 and March 2020, respectively.

Other Program Issues

The Chief of Naval Operations (CNO) recently approved a change in DDG 1000's primary focus from land attack to offensive surface strike. Following a decision to cancel procurement of the long-range land attack projectile, the Navy developed seven courses of action that include, among other things, outlining new missions and associated modifications for the ship. Upon completing these efforts, the Navy, in a January 2018 decision memorandum, changed the ship's mission and, among other things, tasked the program office with examining the cost and schedule implications of removing the gun systems and replacing them with additional launch cells, in addition to providing a summary of requirements to restart DDG 1000 production beyond the three current ships. The DDG 1000's current baseline does not yet reflect the changes resulting from the CNO's decision. Any changes to the baseline may further delay the program's schedule. Since last year, delays in the start of combat system activation and integrating new capability have resulted in an additional 1-year delay to the lead ship's initial operational capability date. Mission change notwithstanding, DDG 1000 will not be ready to deploy until 2021—5 years after the Navy accepted delivery of the HM&E systems.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office stated that, as the lead ship in the Zumwalt class, DDG 1000 has experienced technical and producibility challenges not uncommon to first-of-class ships. It also stated that lessons learned from the lead ship are being applied to follow-on ships, as evidenced by reductions in DDG 1001 and DDG 1002 production labor hours. DDG 1001 completed acceptance trials in February 2018, and according to the program, demonstrated a sharp reduction in deficiencies as compared to the lead ship. The program anticipates preliminary acceptance of DDG 1001 in March 2018 followed by combat system activation in the ship's San Diego homeport later this year. Additionally, the program stated that DDG 1002 construction is 74 percent complete. The program said that in November 2017, after a review of mission requirements, Navy leadership refocused the primary mission of the Zumwalt class on lethal, offensive fires against targets afloat and ashore. The program stated that the Navy's fiscal year 2019 budget request supports this change.

Source: U.S. Marine Corps.

Ground/Air Task Oriented Radar (G/ATOR)

The Marine Corps' Ground/Air Task Oriented Radar (G/ATOR) is a three-dimensional, short-to-medium range, multi-role radar designed to detect, identify, and track threats such as incoming cruise missiles, rockets, and artillery. It will replace five legacy radars. G/ATOR is being acquired in blocks, with later blocks focused on software upgrades. We assessed Block 1, which has an air defense and surveillance role, and have made observations on Block 2, which will determine enemy firing positions and point of impact for incoming fire.

Program Essentials

Program office: Quantico, VA

Prime contractor: Northrop Grumman

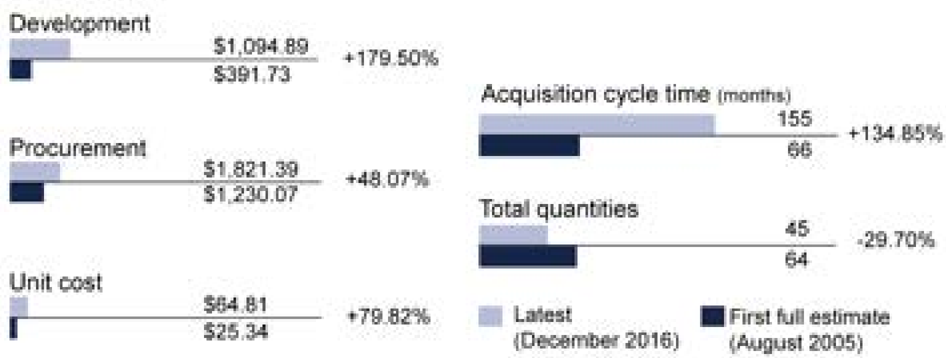
Contract type: Fixed-price-incentive/cost-plus-fixed-fee/firm-fixed-price (low-rate initial production)

Next major milestone: Block 1 initial capability (February 2018)

Program Performance

(Charts not to scale)

(fiscal year 2018 dollars in millions)



Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	…	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	…	●
• Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	○	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical process are in statistical control	○	○
• Demonstrate critical processes on a pilot production line	●	●
• Test a production-representative prototype in its intended environment	●	●

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

G/ATOR Program

Technology Maturity and Design Stability

The program office noted that the system is on track to demonstrate all of its key performance requirements; however, reliability—while improved—remains a concern. In October 2017, the G/ATOR program office reported that all six of its critical technologies were mature and its design stable, with 100 percent of design drawings released. We were unable to assess the system's technological maturity at development start because the necessary information was unavailable. The program did not meet best practices criteria for design stability at the design review. During developmental testing, G/ATOR hardware has proven to be reliable, but software issues have affected the reliability of the overall system. The program office previously reported that it has made software updates to address quality and reliability issues and noted that performance had subsequently improved. In 2017, the program office conducted G/ATOR Block 1 and Block 2 developmental testing and completed an operational assessment of Block 1 to support a planned early fielding decision in January 2018. According to the program office, initial results from these tests indicate that G/ATOR is on track to demonstrate its key performance requirements.

Production Readiness

The G/ATOR program is well into low-rate initial production, but has yet to demonstrate that its production processes are in statistical control. At the program's March 2014 production decision, the contractor had demonstrated G/ATOR production processes to the DOD recommended level, but had not brought them into statistical control, which is inconsistent with best practices. This status is unchanged. According to program officials, they instead track a variety of other production metrics, including ones related to labor efficiency, cost, and quality, and report that the program is meeting its goals in these areas. They reported that the Marine Corps accepted delivery of five production radars in 2017, as planned, with the sixth radar delivered in January 2018.

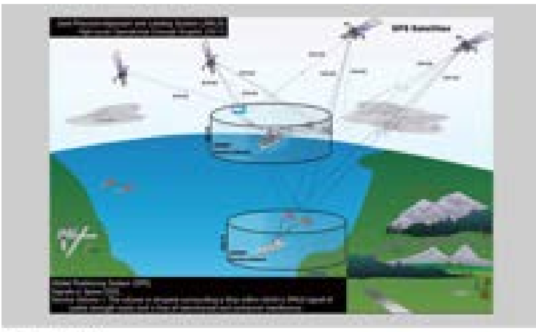
Beginning with radars produced in 2016, the program upgraded G/ATOR's "transmit/receive modules"—key components that process signals from and to the radar—to a new, but mature, gallium nitride (GaN) semiconductor technology. The GaN semiconductors fit inside the G/ATOR system the same way as the older gallium arsenide (GaAs) semiconductors they have replaced. Program officials also expect the GaN technology to achieve better performance with higher reliability at a lower cost by reducing the number of modules required. The program office has budgeted $45 million from fiscal years 2022 through 2024 to refurbish the first six GaAs radars and update them to GaN technology.

Other Program Issues

In 2016, the G/ATOR program office revised its operational test strategy. Originally, the program office planned to conduct initial operational testing with the older GaAs configuration, but DOD's Director, Operational Test & Evaluation raised concerns about testing this legacy configuration as a majority of the planned G/ATOR procurements are with the newer GaN modules. The program office awarded a contract in August 2016 for up to nine GaN radars. The program plans to accept delivery of three of these nine GaN radars in 2018 to support initial operational test and evaluation, ahead of the program's full rate production decision in 2019.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office stated that the G/ATOR program continues to deliver on the cost, schedule, and performance commitments set when it was re-baselined in 2010. It said that six low-rate initial production systems have been delivered with nine additional systems under contract. According to the program office, G/ATOR demonstrated all Block 1 key performance requirements and the capability to meet all Block 2 performance requirements during developmental testing in 2017. The program office also stated that, following a positive operational assessment, the Marine Corps fielded the first two G/ATOR Block 1 systems to support initial operational capability. In the program's view, production processes are in control, technology maturity is appropriate for production, and the program remains on schedule. It also said that a Block 2 operational assessment is on track to support an early fielding decision in 2018, and that three systems will be delivered in 2018 to support initial operational test and evaluation and the full rate production decision in 2019. According to the program office, G/ATOR's operational availability has exceeded the system's requirement and early software quality challenges have been addressed.



Source: U.S. Navy

Joint Precision Approach and Landing System (JPALS)

JPALS is a program to develop a Global Positioning System (GPS)-based aircraft landing system that will allow aircraft such as the F-35 Lightning II and the MQ-25 Unmanned Aircraft System to operate from aircraft carriers and amphibious assault ships. JPALS intends to provide a reliable, sea-based precision approach and landing capability that is effective in adverse weather conditions. JPALS functionality is primarily software-based, although it will also feature off-the-shelf hardware such as antennas and racks.

Program Essentials

Program office: Lexington Park, MD

Prime contractor: Raytheon

Contract type: Cost-plus-incentive-fee (development)

Next major milestone: Low-rate initial production (March 2019)

Program Performance

(fiscal year 2018 dollars in millions) (Charts not to scale)

Total quantities comprise 10 development quantities and 23 procurement quantities.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	○	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	NA	NA
• Demonstrate critical processes on a pilot production line	NA	NA
• Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

JPALS Program

Technology Maturity and Design Stability

Both JPALS critical technologies are approaching maturity, and the program has released 100 percent of its design drawings, which corresponds with a stable design. However, as the program continues to mature its critical technologies through testing—and each technology evolves into a final form, fit, and function—the program may need to revise its design drawings to accommodate these changes, which could compromise JPALS design stability.

JPALS originally entered system development in July 2008 with two technologies that were approaching maturity. The program held a critical design review (CDR) in December 2010, but the design later proved unstable. The program proceeded with development and accepted delivery of eight prototypes. As JPALS approached its production decision in 2013, other military services and civilian agencies decided to continue use of their current landing systems rather than devote resources to invest in JPALS. Given these decisions and similar fiscal concerns, the Navy conducted a review of its precision approach and landing capabilities. As a result, the Navy restructured the JPALS program from seven increments to one, which is intended to support the F-35 Lightning II, the MQ-25 Unmanned Aircraft System, and potentially other future carrier-based aircraft. The restructure also accelerated the development of the program's aircraft auto-land capabilities. The changes associated with the restructure increased the development funding needed by the program and reduced system quantities, resulting in unit cost growth and a critical breach of statutory unit cost thresholds in March 2014.

As a result, the program revised its schedule and milestones, including scheduling a new system-level preliminary design review (PDR) in March 2016, a new development start in June 2016, and a new CDR in May 2017. Because the program repeated these three events, our attainment of product knowledge table assesses the program's knowledge at its original development start and original CDR events, which formed the basis for the program's original business case. This methodology is consistent with how we have previously assessed JPALS and other programs that have repeated key program events.

Program officials reported the release of all JPALS expected design drawings at the new PDR, but subsequently increased the total number of drawings by approximately 4 percent in order to provide additional clarity. In June 2016, Navy leadership authorized the restructured JPALS program to enter the engineering and manufacturing development phase. The program office reported that it awarded a contract in September 2016 to upgrade the eight original prototypes, as well as to procure two additional prototypes for developmental testing. Both the new and upgraded prototypes are intended to be production representative, and the program office plans to use them to provide early operational capability in support of F-35 Lightning II initial capability in fiscal year 2018. These prototypes will also allow the program to demonstrate the JPALS critical technologies in a realistic environment.

For fiscal year 2017, program officials reported that the Navy had installed JPALS prototypes aboard two Nimitz-class aircraft carriers and three amphibious assault ships to support F-35 Lightning II developmental testing, JPALS integrated testing risk reduction, and landing system certification. This testing included 71 total F-35 Lightning II aircraft approaches.

Production Readiness

The May 2017 CDR included an evaluation of JPALS manufacturing plans and did not identify any critical manufacturing processes for the system. Ahead of the planned March 2019 low-rate initial production decision, the program plans to complete software development and a test readiness review by March 2018. The program also expects to receive its first of the two new prototypes purchased for developmental testing in March 2018.

Other Program Issues

Because JPALS is GPS-based, it will need to be compliant with with any updates to DOD's GPS systems, such as integration of "M Code"—a new military GPS signal designed to further improve anti-jamming and secure access to GPS signals for military users. The JPALS program office told us that it contracted for a trade study to determine future M Code integration and implementation options, as well as potential costs and schedule issues.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated as appropriate. Officials noted that JPALS is installed on nuclear aircraft carriers and amphibious assault type ships and provides at-sea, precision approach landing capabilities for F-35 Lightning II, MQ-25, and future ship-based aircraft in virtually any weather condition. JPALS provides alignment, navigation, and surveillance capabilities for low observable and unmanned aircraft and supports auto-land on nuclear aircraft carriers. The program office stated that the JPALS test readiness review supports integrated developmental and operational test events scheduled for fiscal year 2018. Further, the program office stated that JPALS will begin production and permanent shipboard installations in the second quarter of fiscal year 2019. According to the program, JPALS was certified for operational fleet use aboard the USS Wasp (LHD 1) in March 2018.

Sources: Lockheed Martin (left), General Dynamics (right).

Littoral Combat Ship (LCS)

The Navy's LCS is designed to perform mine countermeasures, antisubmarine warfare, and surface warfare missions. It consists of the ship itself, called the seaframe, and the mission package it deploys. The Navy is buying two designs—the Freedom variant, a steel monohull (LCS 1 and odd-numbered ships built by Lockheed Martin), and the Independence variant, an aluminum trimaran (LCS 2 and even-numbered ships built by Austal)—and has awarded contracts for 29 ships with plans for at least three more in fiscal year 2018.

Program Essentials

Program office: Washington Navy Yard, DC

Prime contractors: Austal USA (Independence variant); Lockheed Martin (Freedom variant)

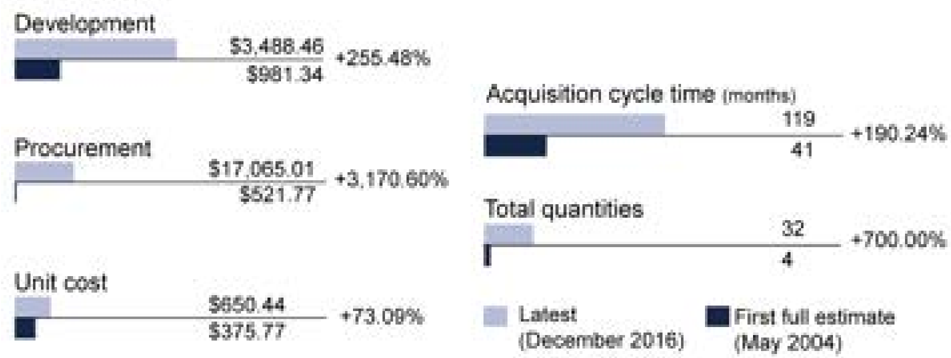
Contract type: Fixed-price incentive (detail design and construction)

Next major milestone: N/A

Program Performance

(Charts not to scale)

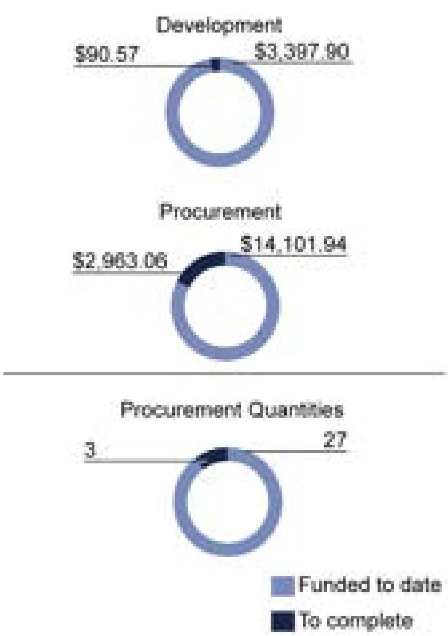
(fiscal year 2018 dollars in millions)



Total quantities comprise 2 development quantities and 30 procurement quantities.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)



Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Detail Design Contract Award**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	○	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	○	●
Product design is stable	**Fabrication Start**	
• Complete basic and functional design to include 100 percent of 3D product modeling	○	●

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

LCS Program

Technology Maturity and Design Stability

Following 13 years of production, the LCS seaframe program office reported that all 18 critical technologies—the total number of technologies for both designs—are mature, including the aluminum hull structure and launch, handling, and recovery system of the Independence variant. In our 2017 assessment, the program assessed only 16 of these 18 technologies as mature. The Navy stated that the aluminum hull structure achieved maturity following the deployment of LCS 2 and LCS 4 and completion of the full shock ship trial conducted on LCS 6 in 2016. However, the Director, Operational Test and Evaluation (DOT&E) noted that the Navy conducted the trial at a reduced severity level and that some equipment was either removed or modified to reduce damage to the ship. The new design of the Twin Boom Extensible Crane, used to launch and recover watercraft, was first installed on LCS 6 and had previously been restricted to operation with only unmanned watercraft. The Navy stated that the crane was qualified in March 2017. The Navy and DOT&E have yet to complete analysis of data for LCS 5 and LCS 6 for shock trials conducted in 2016, or of rough water trials that resulted in damage to both designs over 3 years ago. DOT&E officials stated they initially expected results of the shock trials around February 2017, but as of December 2017 had not received the results.

Since December 2015, the Navy has attributed a series of engineering issues on both variants to shortfalls in crew training, seaframe design, and construction quality. Although some hulls continue to experience propulsion-related failures, the Navy reports that recently delivered seaframes are better constructed and have performed better in trials than previous ships.The Navy accepted delivery of LCS 9 and LCS 12 with no mission- or safety-degrading deficiencies, and officials stated that LCS 11 is not experiencing the same propulsion equipment failures suffered by LCS 9, but has experienced other deficiencies, which the shipbuilder is correcting.

Production Readiness

To date, the Navy has accepted delivery of 11 LCSs and another 15 are in various phases of construction. In 2015, the Navy provided the LCS shipbuilders schedule relief; however, even with revised delivery dates, shipbuilders continue to deliver LCS seaframes behind schedule. Program officials told us that the shipyards will not deliver four LCSs as planned in fiscal year 2017. The Navy accepted delivery of LCS 9 and LCS 12 in September 2017, both approximately 18 months behind schedule. LCS 11 and LCS 14, which were also planned for delivery in 2017, began acceptance trials in December 2017 and delivery has been delayed to approximately February 2018. The Navy still expects to take delivery of four additional seaframes in 2018—LCS 13, LCS 15, LCS 16, and LCS 18—all of which will be delivered, on average, 15 months later than the original schedule.

Other Program Issues

In December 2016, DOT&E reported that the ability of LCS to perform its intended missions depends upon the effectiveness of both the seaframe and its installed mission packages, which have yet to be demonstrated as effective. Additionally, a September 2017 LCS seaframe program office risk assessment noted that if the LCS program is unable to deliver LCSs that are operationally ready, the delay may affect fleet schedules and operations.

Over the past 2 years, the Navy has reported diminishing program cost savings. While program officials stated that some of the decrease is attributable to a change in how the savings were previously calculated, they also cited recent funding instability associated with the Navy operating under a continuing resolution that increased the costs to complete ship construction and offset some of the forecasted savings. Further, the program has also identified schedule and cost risks that may arise if the LCS shipbuilders are unable to sustain their workforces because of uncertainty in their business base after fiscal year 2019. According to the program office, this could occur in part as a result of the acquisition strategy for the new frigate design that is not based on a modified LCS as previously planned.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office stated that there are currently 12 LCSs in the fleet, with another 17 on contract. The program office also stated that, in 2018, LCS shipbuilders delivered or plan to deliver 6 ships, while the program office plans to transfer another 6 to fleet operations. According to the program office, the LCS design is stable, meets all validated and approved requirements, and is in full serial production at both shipyards. The program also noted that it has delivered ships within the budget estimate approved at development start. Additionally, it stated that each ship continues to show improvements over the previous ones, and that the program has stabilized the production cycle. The program office said that LCS shipbuilders delivered two ships, LCS 9 and 14, which did not show mission- or safety-degrading deficiencies during testing and provided the best performance to date for each variant. According to the program office, it has completed required testing for both ship variants and continues to incorporate lessons learned into LCS.

Littoral Combat Ship-Mission Modules (LCS Packages)

Source: U.S. Navy

Littoral Combat Ship (LCS) packages—weapons, helicopters, boats, and sensors launched and recovered from LCS seaframes—will provide mine countermeasure (MCM), surface warfare (SUW), and antisubmarine warfare (ASW) capabilities to the LCS seaframe. The Navy plans to deliver these capabilities incrementally and has set interim requirements that are below the baseline requirements for some increments. We assessed the progress of these mission packages against the threshold requirements that define the baseline capabilities currently expected for each one.

Program Essentials

Program office: Washington Navy Yard, DC

Prime contractor: Northrop Grumman

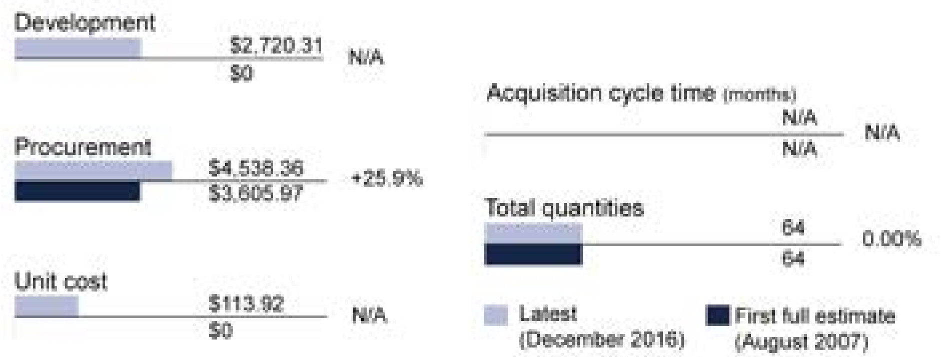
Contract types: Firm-fixed-price and fixed-price incentive (production)

Next major milestone: Surface warfare package initial capability with surface-to-surface missile (second quarter, fiscal year 2018)

Program Performance

(Charts not to scale)

(fiscal year 2018 dollars in millions)



Total quantities comprise 5 development quantities and 59 procurement quantities.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	○	○
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	…	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	NA	NA
• Demonstrate critical processes on a pilot production line	NA	NA
• Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

LCS Packages Program

Mine Countermeasures (MCM)

The Navy designed, produced, and accepted seven MCM packages prior to maturing critical technologies and without demonstrating that the packages met threshold MCM performance requirements. Following these decisions, the Navy has had to fund numerous retrofits and configuration changes, including removal of systems, in recent years within the MCM package.

For three current MCM systems—the Near Surface Detection, Airborne Mine Neutralization, and the Coastal Mine Reconnaissance (CMR)—the Navy has declared initial operational capability (IOC). For CMR, this declaration in July 2017 was underpinned by only limited, shore-based testing. CMR's ship-based testing is scheduled for February 2018. The Navy plans to declare IOC for two additional systems, Remote Minehunting and Unmanned Mine Sweeping, in fiscal year 2019, while IOC for the final system, Buried Minehunting, is planned for fiscal year 2020. Then, following operational testing on the Independence variant of the LCS, the Navy plans to declare IOC for the full MCM suite in fiscal year 2021.

Based on findings from an independent review team, the Navy is replacing the vehicle on the Remote Minehunting system with a 40' unmanned boat called the Unmanned Surface Vehicle (USV). Officials stated the USV will be easier to launch and recover but could be susceptible to wave movement, potentially increasing the difficulty of finding mines. Officials said that USV development is critical to achieving IOC by fiscal year 2021. Afterward, the Navy plans to implement several upgrades and improvement efforts to achieve all threshold requirements.

Surface Warfare (SUW)

The Navy designed and produced SUW mission package systems prior to demonstrating the maturity of key systems, leading to configuration changes and delays to the SUW package. Each SUW package currently consists of two 30-millimeter guns, an armed helicopter, and two rigid-hull inflatable boats. The Navy has accepted six SUW packages to date and, in fiscal year 2018, plans to accept two boat deliveries, but no gun deliveries. The Navy has operationally tested the current SUW package on both LCS variants, found that it met interim performance requirements, and is now fielding it. To meet full threshold requirements, the Navy has adapted a surface-to-surface missile (the Army's Longbow Hellfire) for the maritime environment and is currently testing it. The Navy plans to declare IOC for the adapted missile on the LCS Freedom variant in the second quarter of fiscal year 2018, and then plans to test the missile on the LCS Independence variant in fiscal year 2020. The Navy is also pursuing an over-the-horizon missile as a part of the LCS seaframe program.

Antisubmarine Warfare (ASW)

The Navy reconfigured the ASW package after determining planned systems would not provide adequate capability. The ASW package now consists of the Escort Mission and the Light Weight Tow Torpedo Defense modules. According to the Navy, the ASW systems are mature as they have been deployed and operated by U.S. Navy and foreign navies. Program officials stated that they have resolved excess weight issues that the package faced. The Navy is now planning to meet the threshold requirement and achieve IOC for the ASW package at the end of fiscal year 2019.

Other Program Issues

The Navy will not achieve the capability to meet threshold requirements for all three of the mission package types until 2021, by which time it plans to have taken delivery of at least 25 ships. Additionally, the Navy's plans for the make-up of the small surface combatant portion of its fleet are in flux as the Navy transitions from procuring LCS to frigates. The Navy does not yet know exactly how many LCS or frigates it will procure, nor does the Navy know the extent to which, if at all, the new frigate program will procure any systems from LCS Mission Packages. Despite this uncertainty, the Navy still plans on procuring 64 packages, consistent with the current LCS Mission Package program of record.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office also reported that it will deliver mission package systems to the fleet as the systems mature. It stated that the SUW package achieved IOC in fiscal year 2015 with modules to counter small boat swarming threats and also provide visit, board, search and seizure capability. According to the program office, these modules have embarked on multiple deployments on both LCS variants, and remaining minimum requirements for the SUW package will be met with the addition of the surface-to-surface missile in 2018. Additionally, the program office stated that, in March 2017, it awarded a developmental contract for the ASW package. The program office expects that the ASW capability will deliver in 2019 with performance in excess of minimum requirements. The program office also stated that it is delivering MCM package systems to the fleet as they mature, and parts of the package itself achieved IOC in 2016. The program stated that the MCM USV continues to mature on schedule and will support operational testing of the MCM package in 2020.

Source: U.S. Navy

LHA 6 America Class Amphibious Assault Ship (LHA 6)

The Navy's LHA 6 class will replace the LHA 1 Tarawa-class amphibious assault ships. The ships feature enhanced aviation capabilities and are designed to put Marine Corps assets on hostile shores. The LHA 6 design is based on the fielded LHD 8 and currently consists of three ships. The Navy accepted delivery of the lead ship, LHA 6, in April 2014, and the ship initially deployed in July 2017. The second ship, LHA 7, is under construction whereas the third ship, LHA 8, is under contract, but undergoing design modifications ahead of fabrication start later this year.

Program Essentials

Program office: Washington, DC

Prime contractor: Huntington Ingalls Industries

Contract type: Fixed-price incentive (detail design and construction)

Next major milestone: LHA 8 fabrication start (October 2018)

Program Performance

(Charts not to scale)

(fiscal year 2018, dollars in millions)

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Detail Design Contract Award**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	NA	NA
• Demonstrate all critical technologies in form, fit and function within a realistic environment	NA	NA
• Complete a system-level preliminary design review	●	●
Product design is stable	**Fabrication Start**	
• Complete basic and functional design to include 100 percent of 3D product modeling	●	●

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

Our assessment of design stability reflects the lead ship, LHA 6, only. The Navy has introduced significant design changes on the third ship, LHA 8, which it has yet to finalize.

LHA 6 Program

Technology Maturity, Design Stability, and Production Readiness

The LHA 6 program relies on no critical technologies, which is reflected in an update to our attainment of product knowledge as compared to our 2017 assessment. Following the start of lead ship fabrication, the program achieved a stable design for the first and second ships in the class (LHA 6 and LHA 7). For the third ship, LHA 8, the program is currently implementing significant changes to the basic and functional design to accommodate inclusion of a well deck for amphibious landing craft. This ship will also include a new radar, which program officials identified as a development risk.

LHA 7 launched, or transferred to water, in May 2017, 3 months earlier than planned. At launch, the ship was 72 percent complete. As of November 2017, the ship was approximately 82 percent complete. Program officials said the shipbuilder, Huntington Ingalls, improved performance on LHA 7 as compared to the lead ship, LHA 6, by implementing lessons learned and re-hiring staff from the construction of LHA 6. The shipbuilder also increased its waterfront presence for construction oversight and quality assurance. Despite these actions, the Navy has faced recent production- and testing-related challenges on LHA 7. For example, Navy oversight officials reported the shipbuilder has encountered challenges in aligning the ship's propulsion system and completing system specification testing on schedule. They added that the resulting delays now pose risk to the ship's December 2018 delivery date.

The Navy exercised an option for detail design and construction of LHA 8 in June 2017. Design changes on LHA 8 will be more significant than those on LHA 7, as the Navy is incorporating a well deck to accommodate two amphibious landing craft. Program officials stated that three-dimensional models will be created for the entire ship, unlike the two-dimensional drawings used for the basic and functional design of LHA 6 and LHA 7. According to program officials, 32 percent of LHA 8's detail design was complete as of October 2017, and they project that 90 percent will be completed by the start of fabrication in October 2018. Program design metrics indicate that LHA 8 detail design activities are ahead of schedule.

LHA 8 will also rely on a new subsystem known as the Enterprise Air Surveillance Radar, providing ship self-defense and situational awareness capabilities. Navy officials reported the radar successfully conducted critical design review in August 2017 and the radar would be mature when incorporated on LHA 8. The program, however, has identified the radar as its highest risk during development. LHA 8 is scheduled to be delivered in January 2024.

Other Program Issues

LHA 6 initially deployed in July 2017 and Navy test officials declared the completion of operational testing in August 2017. During this testing, the Navy demonstrated the ability to land, service, and launch all required aircraft and transported over 350 Marines and their equipment from ship to shore. In October 2017, however, DOD's Director, Operational Test and Evaluation (DOT&E) expressed concern that LHA 6 combat systems may not be effective against all threats and noted that some combat system tests are not scheduled to be completed until December 2018. DOT&E requires these data to assess overall combat effectiveness. In addition, the Navy has yet to conduct a multi-day amphibious operation sufficient to assess LHA 6's ability to support all required amphibious warfare activities. Lastly, the Navy does not plan to operationally evaluate the ship's ability to support a complement of 20 Joint Strike Fighter aircraft, one of the ship's requirements, until fiscal year 2020.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. In its response, program officials reported LHA 6 completed initial operational testing, which focused on the ship's ability to support amphibious warfare operations and perform self-defense (including cybersecurity). This testing also assessed the ship's mobility and supporting characteristics. Although program officials stated that the initial operational testing relied, in part, on modeling (simulations), they stated that they also employed a schedule and cost-effective approach for live testing of LHA 6. Specifically, the program conducted live tests in conjunction with fleet exercises to provide visibility into the ship's performance in real-world, operational scenarios. Program officials reported that these tests showed LHA 6 to be both suitable and effective for amphibious operations and demonstrated the ship's ability to move Marines ashore in an adequate timeline. Program officials also indicated they could not evaluate the ship's ability to support a complement of 20 F-35B Joint Strike Fighter aircraft until fiscal year 2020 because the aircraft will not be available until then, at the earliest.

Source: Northrop Grumman.

MQ-4C Triton Unmanned Aircraft System (MQ-4C Triton)

The Navy's MQ-4C Triton—an unmanned aircraft system operated from five land-based sites worldwide—will provide persistent maritime intelligence, surveillance, and reconnaissance (ISR) data collection and dissemination capability. With its design based on the Air Force's RQ-4B Global Hawk air vehicle, the Triton is integral to a family of maritime patrol and reconnaissance systems and part of the Navy's plan to recapitalize its airborne ISR assets by the end of the decade.

Program Essentials

Program office: Patuxent River, MD

Prime contractor: Northrop Grumman

Contract types: Cost-sharing (development)
Fixed-price incentive (initial production)
Firm-fixed-price (initial spares)

Next major milestone: Early operational capability (March 2018)

Program Performance

(Charts not to scale)

(fiscal year 2018 dollars in millions)

Total quantities comprise 4 development quantities and 66 procurement quantities.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	●	NA
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	NA
• Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	○	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	○
• Demonstrate critical processes on a pilot production line	●	●
• Test a production-representative prototype in its intended environment	○	●

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

MQ-4C Triton Program

Technology Maturity, Design Stability, and Production Readiness

The MQ-4C Triton program recently discontinued use of its hydrocarbon sensor—the only critical technology planned for its baseline configuration—after determining that the technology was obsolete and not critical to the aircraft's mission or safe operation. Although the program had matured this technology, and stabilized the MQ-4C system design, prior to entering low-rate production in September 2016, its schedule for attaining this knowledge was inconsistent with best practices. According to best practices criteria, technology maturity and design stability should occur prior to development start and critical design review, respectively, neither of which the program achieved.

Further, Triton production began before the contractor brought its manufacturing processes for wing production under control and, as of November 2017, despite improvements, the contractor has not yet controlled these processes. Not achieving process control can result in low quality, extensive rework and waste, and not meeting cost and schedule targets.

In May 2013, during development of initial prototype aircraft, the Defense Contract Management Agency (DCMA) identified quality deficiencies affecting Triton wings. As a result, program officials stated their office organized a monthly review board in August 2014 to identify the cause of ongoing wing deficiencies and reduce the turn-around time in correcting them. As of November 2017, program officials reported that these efforts have led to an 82 percent reduction in the number of wing deficiencies that occur during production.

Nonetheless, unanticipated development and integration challenges with Triton's baseline software led the Navy to modify its acquisition strategy, allotting additional time for the development and integration of future capabilities. Subsequently, the start of full-rate production has been delayed by over 3 years, from September 2018 to May 2021. The program also plans to increase the quantity of aircraft acquired during low-rate production from 10 to 15, increasing the risk that more aircraft units will require design changes after the Navy operationally tests Triton and demonstrates its capabilities beginning in 2020.

The system's baseline software configuration is expected to achieve Early Operational Capability in March 2018. Meanwhile, the program is developing new Triton capabilities that will be implemented in two future upgrade packages. The first upgrade, which the program plans to integrate into production beginning in 2020, will support enhanced intelligence capabilities. The second upgrade will include electronic defense upgrades and an aircraft avoidance radar system. This upgrade is scheduled to be integrated into the production line for the 19th production aircraft, which is slated for delivery in fiscal year 2024.

Other Program Issues

Program officials stated that two aircraft have been delivered to the Triton squadron in Point Mugu, California in November and December 2017 to support Early Operational Capability in March 2018. The two aircraft will be equipped with intelligence, surveillance, and reconnaissance capability, but the Navy has deferred other capabilities to future software builds following program cost and schedule growth. Program officials added that training for Triton air crew and maintainers is ongoing.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office also stated that the MQ-4C Triton program continues to demonstrate success during early operational flight and ground testing. Additionally, it said the contract for the program's third low-rate production lot was recently awarded and future capability development work continues, as does retrofit planning. Program officials also confirmed that two aircraft have been delivered in support of an upcoming operational test period and baseline configuration Early Operational Capability.

Source: Northrop Grumman Systems Corporation.

MQ-8 Fire Scout

The Navy's MQ-8 Fire Scout unmanned aerial vehicle is intended to provide real-time imagery and data in support of intelligence, surveillance, and reconnaissance missions. The MQ-8 system is comprised of one or more air vehicles with sensors, a control station, and ship equipment to aid in vertical launch and recovery. The air vehicle operates from ships, such as the Littoral Combat Ship, and the ground. The MQ-8 is intended for use in various operations, including surface, anti-submarine, and mine warfare and it includes B and C variants. We assessed the latest variant, the MQ-8C.

Program Essentials

Program office: Patuxent River, MD

Prime contractor: Northrop Grumman

Contract type: Fixed-price incentive (production)

Next major milestone: Initial capability (April 2019)

Program Performance

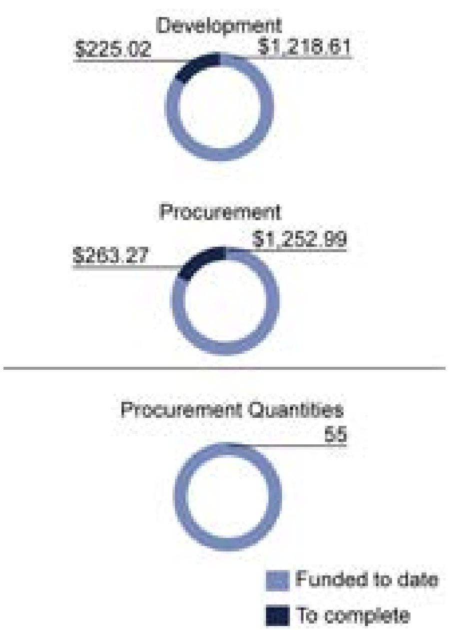
(Charts not to scale)

(fiscal year 2018 dollars in millions)

Program costs and quantities include all MQ-8 variants. Total quantities comprise 9 development quantities and 55 procurement quantities.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)



Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	…	…
• Demonstrate all critical technologies in form, fit and function within a realistic environment	…	…
• Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	○	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	…	…
• Demonstrate critical processes on a pilot production line	●	●
• Test a production-representative prototype in its intended environment	●	●

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

MQ-8 Fire Scout Program

Technology Maturity and Design Stability

The MQ-8C variant relies on mature technologies and has a stable design. According to program officials, the MQ-8C shares 90 percent of its technology with the previously developed MQ-8B. The primary differences between the variants are two structural modifications made to accommodate the MQ-8C's larger airframe and fuel system.

Despite being developed separately from the B variant, the MQ-8C did not have a separate development start decision review because it was not required by the Navy when the program was restructured. Instead, in April 2012, the Navy initiated MQ-8C acquisition under its rapid deployment capability procurement process, which enabled the program to bypass many standard acquisition practices designed to reduce risk with the goal of a speedier acquisition cycle time. Despite a streamlined process, the Navy will have taken 7 years from program start to planned initial operational capability. After the April 2012 initiation, the Navy completed an MQ-8C critical design review in January 2013, followed by a first flight of the aircraft in October 2013. The program will continue with developmental testing and plans to transition to initial operational test and evaluation in April 2018.

Production Readiness

The MQ-8C is in production, but the program has yet to demonstrate that its critical manufacturing processes are in statistical control—an approach inconsistent with best practices. The program does not collect data on statistical process controls or assess process capabilities using manufacturing readiness levels. Rather, the program office collects metrics on the status of production from the prime contractor, such as discovery of manufacturing defects. Program officials noted that the MQ-8C has a commercial airframe procured by the government and provided directly to the prime contractor as government-furnished equipment for conversion to an MQ-8C.

The Navy accepted delivery of 30 MQ-8B aircraft before it embarked on MQ-8C production in April 2012. As of September 2017, the Navy had taken delivery of 19 MQ-8C aircraft and had placed an additional 11 MQ-8C aircraft under contract. In fiscal year 2017, Congress appropriated $41.2 million for an additional four MQ-8C quantities beyond the Navy’s requirement for 30 aircraft. According to the program, the funding was only sufficient to procure three aircraft, which were put under contract in December 2017.

The Navy also plans to acquire all its MQ-8C aircraft, effectively, as low-rate initial production units. According to DOD acquisition policy, if a program’s low-rate initial production quantity exceeds 10 percent of the total production quantity, the program must provide a rationale for these quantities in a report to Congress. Although the program completed the documentation requirements for a full-rate production decision in June 2017, officials state that the program had already placed the remaining 14 of its 30 required quantities under contract, which precluded the need for a decision to ramp up production.

Other Program Issues

The program office reported that it plans to start operational testing in April 2018, a delay of seven months since our 2017 assessment. The program attributed the delay to the lack of availability of a Littoral Combat Ship for testing. The program has used the additional time to correct known integration deficiencies. In addition, the program plans to demonstrate initial operational capability in December 2018, a delay of 7 months since our previous assessment. That delay was due, in part, to the developmental and operational test team’s addition of an at-sea test to collect data for maritime targets that increased the time needed to test by 5 months.

In June 2014, the Secretary of Defense certified that, among other things, the continuation of the program was essential to national security. This certification allowed the program to continue after it reported to Congress that it had incurred unit cost growth in excess of statutory critical thresholds. The Navy restructured the program and revised its planned quantities for both variants, in recognition that the MQ-8C could fly over twice as long than the MQ-8B, which reduced the total quantity of MQ-8 required to support the Littoral Combat Ship.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program stated that the MQ-8 program is executing with no significant issues. It said that the MQ-8C completed its operational test readiness review and will start initial operational test and evaluation in April 2018. The program also noted that the MQ-8C is continuing to work towards initial operating capability to be achieved in December 2018. According to the program, the MQ-8B completed development testing aboard a Littoral Combat Ship in March 2018. As part of their technical comments, program officials identified cost and quantity changes that the program intends to reflect in a future Selected Acquisition Report.

Source: Raytheon Corp.

Next Generation Jammer Mid-Band (NGJ Mid-Band)

The Navy's Next Generation Jammer (NGJ) is an external jamming pod system that will be fitted on EA-18G Growler aircraft. It is expected to replace the ALQ-99 tactical jamming system and provide enhanced airborne electronic attack capabilities to disrupt adversaries' use of the electromagnetic spectrum for purposes such as radar detection. The Navy plans to field this system, which covers mid-band radio frequencies (formerly called NGJ Increment 1), in 2021. The Navy is planning separate programs for low- and high-band systems.

Program Essentials

Program office: Patuxent River, MD

Prime contractor: Raytheon

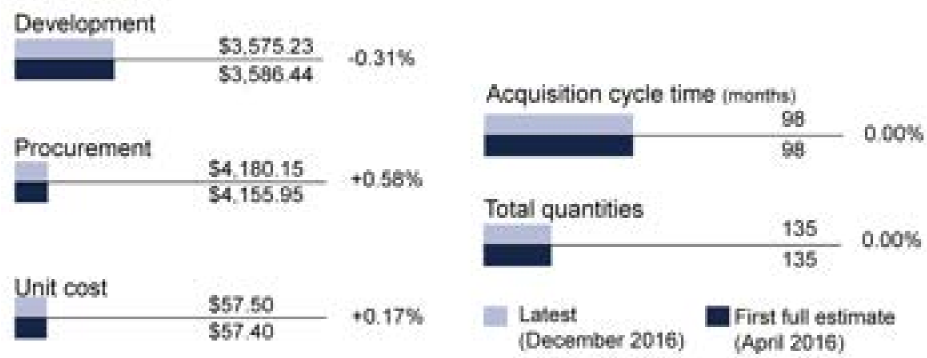
Contract type: Cost-plus-incentive-fee (development)

Next major milestone: Low-rate initial production (September 2019)

Program Performance

(Charts not to scale)

(fiscal year 2018 dollars in millions)



Total quantities comprise 4 development quantities and 131 procurement quantities.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	●	●
• Test a system-level integrated prototype	○	○
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	NA	NA
• Demonstrate critical processes on a pilot production line	NA	NA
• Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

NGJ Mid-Band Program

Technology Maturity and Design Stability

The NGJ Mid-Band program has seven critical technologies that are all approaching maturity and a stable design. This design stability could be disrupted, however, as technologies continue to mature up to and potentially beyond the system's start of production in September 2019.

The program entered system development in April 2016 with its critical technologies approaching maturity. These technologies include two separate arrays—each with different transmit/receive modules, circulators, and apertures—as well as a power generation system. The program plans to rely on subsystem integration tests scheduled for 2019 to fully mature its critical technologies.

The NGJ program completed its critical design review in April 2017 and, as of August 2017, the contractor had released 100 percent of design drawings. This current design stability is premised on assumptions about the final form, fit, and function of critical technologies—and how these technologies will perform in a realistic environment—that may not come to fruition as NGJ critical technologies continue to mature. Further, program officials stated that the methodologies used to conduct a structural analysis of the pod (in support of the critical design review) have since proven to be incomplete and flawed. The program office plans to conduct this analysis again and implement any needed design changes by May 2018. The program office has also not yet tested a system-level integrated prototype of the jamming pod, which GAO identified best practices recommends completing by critical design review. The program now plans to complete this prototype testing on an EA-18G in May 2019, about 4 months before the start of production in September 2019.

Production Readiness

The program currently plans to demonstrate its critical manufacturing processes prior to the September 2019 start of production, consistent with best practices. At the same time, the program does not plan to test a production-representative prototype, or complete system-level developmental testing, until 9 months and 1 year, respectively, after production starts. Although DOD policy allows some degree of concurrency between initial production and developmental testing, we have previously found that beginning production before demonstrating that a system will work as intended increases the risk of needing substantial design changes and costly modifications to already-produced systems.

Program officials do not consider this concurrency to pose risk to their ability to complete the NGJ Mid-Band program within current cost and schedule estimates. According to program officials, the program's extensive use of contractor and government systems integration labs, along with the use of test chambers to evaluate pod performance, will significantly reduce risk prior to the program's planned start of production. Officials also stated testing in these labs will also help address one of the main software development risks: the concurrent development of software for the pod and the EA-18G aircraft. Program officials also plan to conduct mission representative flight tests for an operational assessment that will inform the Navy's NGJ Mid-Band production decision.

Other Program Issues

In September 2015, the Under Secretary of Defense for Acquisition, Technology and Logistics approved NGJ as the first program in the "Skunk Works" pilot, which aims to eliminate non-value added processes in order to deliver capabilities on time and within budget. NGJ officials stated the Skunk Works designation was beneficial to the program since they were able to streamline reporting requirements, delegate documentation approval authority to lower levels, and speak directly with senior leadership.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. According to the program office, it has completed significant prototyping of key systems and subsystems that contain the critical technologies, an approach that officials said reduces risk to acceptable levels for system development. The program office stated that critical design review revealed deficiencies in pod structure design. All other subassemblies, software, and critical technologies are unaffected, according to the program. Further, the program office stated that it is assessing schedule impacts due to structural redesign and developing strategies to mitigate the effect of this redesign in order to provide capability to the fleet by 2021.

Source: U.S. Navy

Offensive Anti-Surface Warfare Increment 1 (OASuW Inc 1)

The Navy's OASuW Inc 1 program plans to develop an air-launched, long-range, anti-surface warfare missile to address an urgent operational need. The program is using an accelerated acquisition approach and has leveraged previous technology demonstration efforts. It plans to field an early operational capability on Air Force B-1 bombers in 2018 and Navy F/A-18 aircraft in 2019. DOD also plans to develop an additional capability to address future threats. We assessed Increment 1.

Program Essentials

Program office: Patuxent River, MD

Prime contractor: Lockheed Martin

Contract type: Cost-plus-incentive-fee (development)
Fixed-price incentive (low-rate initial production)

Next major milestone: Early operational capability with B-1 bombers (September 2018)

Program Performance

(Charts not to scale)

(fiscal year 2018 dollars in millions)

Total quantities comprise 13 development quantities and 135 procurement quantities.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	○	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	●	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	○
• Demonstrate critical processes on a pilot production line	NA	NA
• Test a production-representative prototype in its intended environment	○	●

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

OASuW Inc 1 Program

Technology Maturity and Design Stability

The OASuW Inc 1 program has mature technologies and a stable design. The program fully matured its six critical technologies before its December 2016 production decision. According to program officials, critical technologies were initially matured through a combination of modeling and simulation and flight tests aboard aircraft that did not involve any missile launches. In August 2017, the program office further demonstrated these technologies and the design in the first system-level flight test of a launched missile. In addition, all of the program's design drawings are complete and, according to program officials, the Navy has qualified all Inc 1 subsystems, which means they have been tested to ensure that they can meet requirements.

Production Readiness

The manufacturing processes for the OASuW Inc 1 are approaching maturity and the main challenges are related to how the services and contractor will manage a shared production line. The program leverages the airframe and production facilities of the Air Force's Joint Air-to-Surface Standoff Missile-Extended Range (JASSM-ER) program, which the program reports decreases production risks. The program's top priority is to produce missiles to support an early operational capability for the B-1 bomber with planned deliveries beginning in the fourth quarter of fiscal year 2018. According to officials, this priority has caused the program to defer its planned production of test missiles for the Navy by 2 months but it is not expected to delay early operational capability for the F/A-18. The program will update its manufacturing readiness assessment as a part of a program review scheduled for February 2018.

Other Program Issues

According to program officials, test range availability and limitations have delayed certain program test events, but have not yet affected the program's overall schedule. The program will also rely on modeling and simulation to evaluate the system's performance in an operational threat environment, so the completion and accreditation of key facilities and models is critical for the program.

Changes in the Navy's plans for OASuW Inc 2 could affect the strategy for the Inc 1 program. Maintaining the program's schedule is the primary concern for OASuW Inc 1 as it intends to address an urgent operational need. The program's current accelerated acquisition approach requires concurrency between developmental testing and initial production. Our past work has shown that beginning production before demonstrating that a design is mature and will work as intended increases the risk of discovering deficiencies during production that could require design changes, costly modifications, and retrofits. The program has accepted this risk and mitigated it, in part, by limiting the number of missiles needed until a second increment could be fielded.

However, the Navy has discontinued Increment 2 planning and is re-examining its options for addressing future threats. The Navy plans to procure an additional 25 missiles during OASuW Inc 1 production to fill the gap until a future capability is available. The program plans to incorporate improvements to the OASuW Inc 1 for later missiles in response to evolving threats. Further, program officials noted that certain JASSM-ER upgrades may be leveraged to provide OASuW Inc 1 with additional capabiliy. The program office expects to receive guidance on the long-term direction of the Inc 1 program at its February 2018 program review.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. Officials noted OASuW Inc 1 is an accelerated acquisition program intended to fill an urgent, unmet maritime warfighting requirement and that schedule is an elevated priority. The program noted that an integrated government/industry team manages techincal and programmatic risks including those related to concurrent development, testing, and production. It also stated that oversight is provided through monthly meetings chaired by the senior Navy acquisition authority. The program stated that the Navy has assessed hardware design and manufacturing readiness as mature to support production of the first operational units. Further, the program expects an early operational capability for the Air Force will be fielded no later than the fourth quarter of fiscal year 2018. The program also stated that it is ahead of schedule for fielding an early operational capabilty on Navy aircraft in the following year.

Source: General Dynamics Electric Boat.

SSBN 826 Columbia Class Ballistic Missile Submarine (SSBN 826)

The Navy's Columbia class (SSBN 826) is planned to replace the current fleet of Ohio class ballistic missile submarines as they begin to retire in 2027. The program seeks to provide a sea-based, strategic nuclear deterrent that will remain in service through 2080. Navy plans call for the lead ship to make its first patrol in fiscal year 2031.

Program Essentials

Program office: Washington Navy Yard, DC

Prime contractor: General Dynamics Electric Boat

Contract type: Combination of cost-plus-incentive-fee and cost-plus-fixed-fee (development)

Next major milestone: Design review (April 2020)

Program Performance

(Charts not to scale)

(fiscal year 2018, dollars in millions)

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Detail Design Contract Award**	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	○	○
• Demonstrate all critical technologies in form, fit, and function within a realistic environment	○	○
• Complete a system-level preliminary design review	●	●
Product design is stable	**Fabrication Start**	
• Complete basic and functional design to include 100 percent of 3D product modeling	NA	NA

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

SSBN 826 Program

Technology Maturity

The Columbia Class program's Technology Readiness Assessment (TRA) identifies only two critical technologies. However, the Navy did not follow our identified best practices for assessing critical technologies and, as a result, we believe the TRA underrepresented the number of critical technologies in the program. The TRA identified the ship's carbon dioxide removal system and one major technical feature of the stern, the Stern Area System, as critical technologies. The carbon dioxide removal system has matured since the TRA and no longer requires active risk mitigation efforts. The Stern Area System, however, requires continued development. Four additional technologies meet our criteria for critical technologies: the Integrated Power System, nuclear reactor, propulsor/coordinated stern, and Common Missile Compartment. The Navy did not assign these systems technology readiness levels since they were not identified as critical technologies in the TRA, but we assessed that they require additional development and testing to fully mature them. For example, the Navy is still working to refine the design for the nuclear reactor plant and propulsor/coordinated stern. Additionally, the Navy has yet to test final prototypes for the Integrated Power System and the propulsor/coordinated stern; testing for these technologies is planned to occur between fiscal years 2018 and 2020. Navy officials stated that they have active risk mitigation plans in place for these technologies.

Design Stability

The Columbia Class program is prioritizing design stability prior to the start of construction of the lead submarine of the class. The program plans to complete 100 percent of design arrangements, including 3D product modeling, and 83 percent of design disclosures prior to the start of construction of the lead submarine. However, the design will likely remain immature once construction starts even if the program can complete 83 percent of design disclosures because some of the key technologies are not fully mature and detail design work is proceeding with notional or placeholder data representing key systems. For example, the Navy has entered the detail design phase for the ship with incomplete data for significant components of the design, such as the nuclear reactor plant and Integrated Power System. We have previously reported that concurrency of technology development and design increases the risk of design rework and can result in negative cost and schedule impacts.

Production Readiness

The Navy plans to begin lead ship construction in fiscal year 2021 and expects to build the lead ship in 84 months. This timeframe is significantly shorter than the Navy has achieved on any recent lead submarine, including those during high levels of Cold War submarine production. Moreover, the Navy expects that the Columbia Class will be built as quickly as was planned for the lead Virginia Class submarine—a submarine of less than one and one-half the size and estimated construction labor hours of Columbia. In an effort to achieve its aggressive delivery schedule, the Navy is planning to start building areas of the lead ship in advance of the planned lead ship authorization in fiscal year 2021. The Navy intends to start construction as early as 2019—2 years prior to the planned fiscal year 2021 ship authorization—on some of the submarine's structure. This includes construction on the stern, bow, and mission command and control module as early as 6 months before the planned fiscal year of authorization, which officials stated was because of the disruptive effects of delays to these components that are critical to ensuring an on-time delivery. Accelerating construction could further exacerbate design instability issues since some of the components still being designed are in the areas the Navy is considering for early construction.

Other Program Issues

In a December 2017 report, we determined that it is more likely than not that the Columbia Class program will exceed the Navy's $128 billion (then-year dollars) estimate of total acquisition cost. Specifically, the Navy has budgeted the submarine to a confidence level for the program that is lower than what experts recommend, a decision which may not account for a sufficient amount of program risk due to ongoing concurrency between technology development and design.

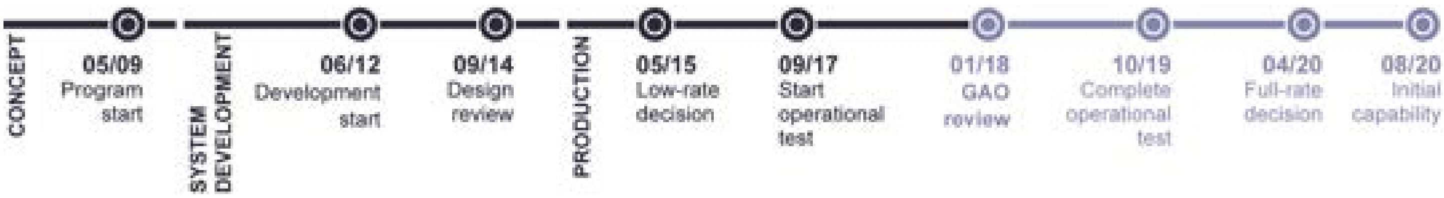
Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. Program officials stated that the TRA for the Columbia Class program met DOD, Navy, and statutory requirements. Program officials also stated that Columbia Class program is positioned to provide needed capability, at an affordable price, on time to meet national strategic deterrent requirements. They indicated that the Columbia Class program plans for 83 percent completion of design products by the start of lead ship construction to lower costs.

Source: U.S. Navy

Ship To Shore Connector Amphibious Craft (SSC)

The Navy's SSC is an air-cushioned landing craft intended to transport personnel, weapon systems, equipment, and cargo from amphibious vessels to shore. SSC is the replacement for the Landing Craft, Air Cushion, which is approaching the end of its service life. The SSC is designed to deploy in and from Navy amphibious ships that have well decks, such as the LPD 17 class, and will support assault and non-assault operations.



Program Essentials

Program office: Washington, DC

Prime contractor: Textron Inc.

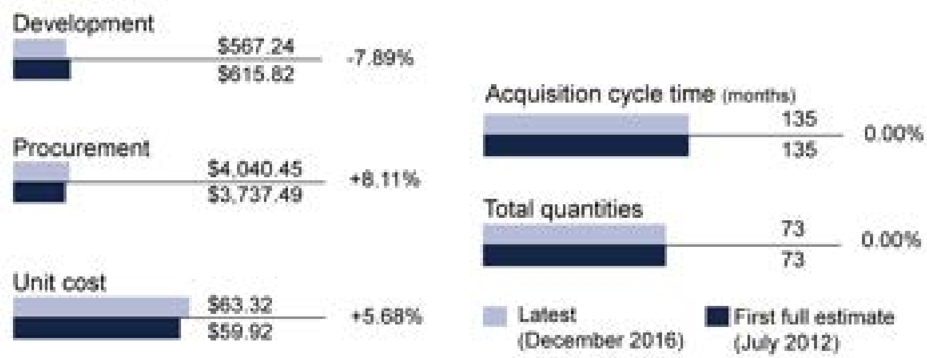
Contract type: Fixed-price incentive (development)

Next major milestone: Completion of operational testing (July 2019)

Program Performance

(Charts not to scale)

(fiscal year 2018 dollars in millions)



Total quantities comprise 1 development quantity and 72 procurement quantities.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	●	●
• Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	○	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	○
• Demonstrate critical processes on a pilot production line	●	●
• Test a production-representative prototype in its intended environment	○	○

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

SSC Program

Technology Maturity and Design Stability

SSC's one critical technology is mature. Although the SSC's design was not stable at its design review in 2014, it has since achieved stability. The program developed a design change for the gearbox to address premature wear, the second design change related to this issue. The gearbox has passed factory acceptance and first article testing, and the revised design has been incorporated into all craft except the test and training craft. Recent tests of the engine revealed issues with lubication oil leakage and its control system, which program officials stated have been addressed with design and software changes.

In May 2015, the Navy's operational test agency reported that the steep angle of SSC's loading ramp may create operational hazards for certain vehicles. Program officials stated that they have developed a solution using wooden beams that will be laid on the ramp to reduce the angle when necessary. While program officials stated that the Navy is satisfied with this approach, it will not be able to test this and other operational aspects of the craft until testing of the first craft, which is scheduled for the second quarter of fiscal year 2018 through the third quarter of fiscal year 2019.

Production Readiness

The program entered low-rate production in May 2015 after demonstrating that all materials, manpower, tooling, and facilities were proven and available to meet the low rate production schedule, as recommended by DOD guidance. However, according to best practices, programs should also take the additional steps to demonstrate that manufacturing processes are in statistical control prior to production start, which the program has not done. Specifically, critical processes should be repeatable, sustainable, and consistently producing parts within the quality standards.

The program has experienced delays in its production schedule. Nine SSC craft are under contract, with six already under construction. The program expects to accept delivery of the initial test and training craft in April 2018, a 7-month delay compared to the schedule at the time of our last review; there had also been previous delays. The program also expects a similar slip in delivery of the second craft. According to the program, work required to address the engine issues discovered during testing was one source of these delays. Another source of delays has been the supply of propeller blades, 12 of which are needed for each craft. A fire destroyed the manufacturer's facility in 2015, and production yield from the replacement facility has been unreliable. Blades for the first two craft have now been delivered; program officials also stated that the manufacturer began construction of a new facility in December 2017, and they are optimistic that yields will continue to increase.

The program will have its first opportunity to demonstrate that the SSC design meets requirements and that no rework is needed when the test craft is delivered. Testing of this craft will occur while the contractor produces eight other SSC craft. Our previous work has found that concurrent testing and production increases the risk of discovering deficiencies that could require costly design changes and modifications to units already produced.

Other Program Issues

The program is currently negotiating the terms of its next production contract with Textron. Officials also stated that the number of craft that will ultimately be funded in 2018 is still uncertain, but may be more than two. Officials stated that this uncertainty has made the negotiations more challenging, in part because of the program's view that the minimum sustainable annual economic order quantity for the SSC is five per year. The program's plans had called for a second source to introduce competition, but officials stated that the currently anticipated quantities of fewer than 10 craft per year make this infeasible because of the percieved need for an annual economic order quantity of five. Program officials are seeking ways to incentivize Textron to pursue more competition at the subcontractor level, and also stated that a second source remained a possibility if quantities increased in future fiscal years.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program stated that, with regard to technology maturity and design stability, ramp angle risk was reduced through multiple successful tests in May 2017 using SSC simulated geometry on existing landing craft. It said recent test and training craft delivery delays were based on first of class testing challenges that the program does not expect to affect later craft. According to the program, propeller blade production has improved to meet current quantity requirements, and the program expects additional productivity gains. It also stated that manufacturing processes continue to stabilize and reflect continuous improvement from craft to craft, with current rework dropping from 20 percent on craft 101 to 1 percent on craft 106. The program noted that craft deliveries remain on track to support August 2020 initial capability. The program said that, in April 2017, it issued a solicitation for the next production contract. The program plans to update the solicitation's quantities, which the program will determine based on funding from fiscal year 2018 appropriations.

Source: General Dynamics NASSCO

John Lewis Class Fleet Replenishment Oiler (T-AO 205)

The John Lewis Class Fleet Replenishment Oiler (T-AO 205) program will replace the Navy's 15 existing Henry J. Kaiser Class Fleet Oilers (T-AO 187), which are nearing the end of their service lives. The primary mission of the oiler is to replenish bulk petroleum products, dry stores and packaged cargo, fleet freight, mail, and personnel to other vessels at sea. The Navy plans to procure a total of 17 ships, with construction of the lead ship beginning in September 2018, and proceeding at a rate of one ship per year until 2033.

Program Essentials

Program office: Washington Navy Yard, DC

Prime contractor: General Dynamics National Steel and Shipbuilding Company (NASSCO)

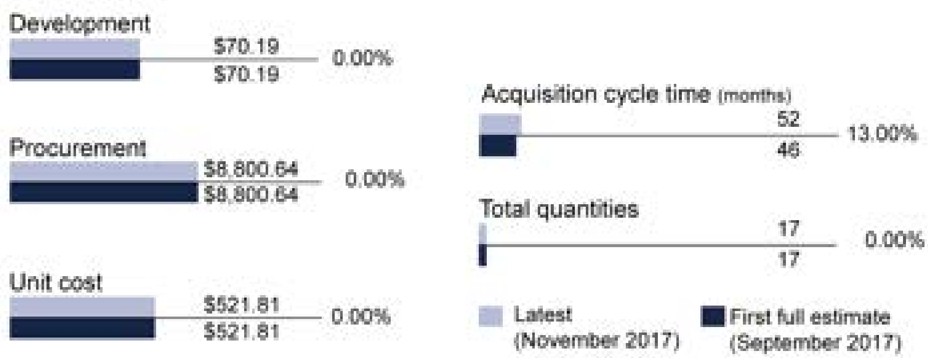
Contract type: Fixed-price incentive (detail design and construction)

Next major milestone: Design review (February 2018)

Program Performance

(Charts not to scale)

(fiscal year 2018 dollars in millions)



Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	●	●
• Complete a system-level preliminary design review	○	●
Product design is stable	**Fabrication Start**	
• Complete basic and functional design to include 100 percent of 3D product modeling	NA	NA

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

T-AO 205 Program

Technology Maturity

The Navy matured Lewis class critical technologies prior to initiating detail design, which is a best practice in shipbuilding. In 2014, the Navy identified three critical technologies for the Lewis-class design. All three technologies were associated with a new underway replenishment system for transferring cargo to other ships. When the program conducted a Technology Readiness Assessment, the results of land-based and at-sea prototype testing of these technologies showed that they were fully mature, and the Navy determined that no further technology development would be necessary. We have previously reported that fully maturing technologies prior to beginning detail design is an important step in reducing risk of cost growth and schedule delay. In 2017, the Navy opted to drop one of the three technologies, the Heavy e-STREAM cargo delivery system, designed to deliver loads too heavy for the standard e-STREAM system. Navy officials told us that they originally needed the Heavy system to deliver power modules for the F-35 Lighting II, but the Navy has since decided to use aircraft to deliver these modules, thus negating the requirement. As a result, Lewis class ships will now be able to deliver all of their solid cargo using the standard system.

Design Stability and Production Readiness

The Navy leveraged commercial vessel designs to minimize Lewis class design and construction risks, and plans to have all fifteen three-dimensional design zones completed by the start of lead ship construction. This level of design completion is consistent with the GAO-identified best practice for shipbuilding to have 100 percent of three-dimensional models completed by the start of construction. In June 2016, the Navy awarded a detail design and construction (DD&C) contract to General Dynamics NASSCO. According to program officials, the detail design effort is 26 percent complete, as of September 2017, and progress to date will support the planned September 2018 start of construction. The Lewis class features a modern double-hull construction to prevent environmental requirements from interfering with the ships' ability to dock at ports-of-call, a design that is standard for commercial oilers and was included in the final three Kaiser-class oilers, the predecessor to the T-AO 205.

Navy officials stated that Lewis class cybersecurity requirements have changed since the June 2016 DD&C award, but they do not expect the revisions to cause any changes to ship hardware or to the allocated baseline. The Navy has requested a proposal from the contractor and plans to modify the contract to meet these new requirements before conducting a Critical Design Review (CDR) in March 2018. At the CDR, the program plans to evaluate the stability of the ship design and revalidate that it is sufficient to meet Lewis class performance requirements. Ahead of CDR, the program has already identified and closed several design risks, including potential overloads on the ship's generators. Several other risk areas remain open, however, relating to cavitation caused by the ship's propeller and the integration of the ship's propulsion system, which the Navy and NASSCO are working to mitigate.

Other Program Issues

As a future component of its Combat Logistics Force, the Lewis-class ships will have the capability to operate in a combat environment. Program officials stated that the current design affords sufficient space, weight, and power to enable installation of various systems to counter threats from anti-ship missiles, and torpedoes. However, the Navy's budget request for fiscal year 2018 requested funding only for a torpedo defense system on the first two Lewis class ships. Program officials report that they expect the Lewis class will primarily rely on other ships for defense.

In 2016, the House Committee on Armed Services requested the Navy study the effect of switching the Lewis class program to a construction rate of two ships funded per year. In June 2017, the Navy produced the requested study, but in the absence of any directed changes from Congress, the Navy continues to plan for a rate of one ship funded per year.

The Navy awarded what it refers to as a "block buy" contract for construction of the first six ships in June 2016. This contract is structured under mostly fixed-price incentive contract terms and includes a target price for the design and construction work for the first six ships totaling just over $3 billion. The contract award preceded the May 2017 preliminary design review by almost a year because, according to program officials, adapting commercial ship designs for Navy use and validating a preliminary design requires information that can only be developed through the detail design phase of the program. In September 2017, the Assistant Secretary of the Navy for Research, Development, and Acquisition authorized the program to enter into both the production and deployment phase.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. According to the program office, the President's Budget for fiscal year 2019 proposes a 3 ship increase to the program at the rate of one additional ship per year in fiscal years 2019, 2021, and 2023. This plan would increase the total number of ships acquired to 20. The program office stated that design changes subsequent to the preliminary design review have retired the cavitation risks posed by the propeller. They also clarified that the program's baseline still includes a torpedo defense system for all ships.

Source: © Sikorsky Aircraft Corporation, a Lockheed Martin Company

VH-92A Presidential Helicopter Replacement Program (VH-92A)

The Navy's VH-92A program provides new helicopters for safe, reliable, and timely transportation for the President of the United States and other parties as directed by the White House Military Office. It replaces the current Marine Corps fleet of VH-3D and VH-60N aircraft. A successor to the VH-71 program, canceled by the Navy due to cost growth, schedule delays, and performance shortfalls, the VH-92A is expected to provide improved performance, survivability, and communications capabilities, while offering increased passenger capacity.

Program Essentials

Program office: Patuxent River, MD

Prime contractor: Sikorsky Aircraft Corporation, a Lockheed Martin Company

Contract type: Fixed-price incentive (development)

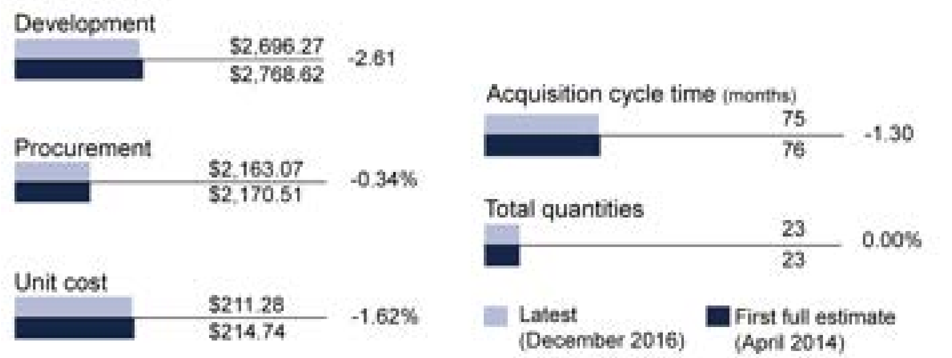
Firm-fixed-price (production; planned)

Next major milestone: Low-rate initial production (March 2019)

Program Performance

(Charts not to scale)

(fiscal year 2018 dollars in millions)



Total quantities comprise 6 development quantities and 17 procurement quantities.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	NA	NA
• Demonstrate all critical technologies in form, fit and function within a realistic environment	NA	NA
• Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	○	●
• Test a system-level integrated prototype	○	○
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or that critical processes are in statistical control	NA	NA
• Demonstrate critical processes on a pilot production line	NA	NA
• Test a production-representative prototype	NA	NA

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

VH-92A Program

Technology Maturity

The program contains no immature critical technologies, due to its use of an existing helicopter and components. However, the program is using a government-designed mission communications system (MCS), which is the only technology that is not in use in another aircraft in the same configuration, as required for the VH-92A. While software development is on schedule, the MCS has yet to be government flight tested. To date, the VH-92A contractor has installed an updated version of MCS on the developmental aircraft for initial contractor-led testing. The program expects to release software updates, following an operational assessment planned for December 2018, that will address deficiencies identified during earlier testing.

Design Stability

Since its July 2016 critical design review, the VH-92A program has increased its expected number of design drawings by 2.4 percent. The increase is due to contractor incorporation of wide-band line-of-sight and formation lights, which were existing requirements. Also, additional drawings were needed based on redesign of wiring harnesses for selected equipment to include filters for protection against electronic radio frequency damage.

Engineering development model aircraft have completed first flights and are now undergoing contractor-led testing. In addition, three of four planned production representative aircraft, built under the development contract, are now undergoing modifications, in preparation for integration of VH-92A-specific subsystems. Meanwhile, the program is pursuing technical improvements related to the S-92A propulsion system, which has yet to meet the VH-92A engine start requirement. According to program officials, they expect the contractor to complete the necessary engineering analysis of solutions for meeting this performance requirement by October 2018. Program officials noted that, should they not meet the aforementioned schedule, they do not intend to delay production and will continue working on a solution to support the start of operational testing in December 2019. The program office is also monitoring a potential shortfall in the aircraft's ability to meet the landing zone suitability "no damage to lawn/landing zone surface" threshold. Currently, the combined exhaust from both the engine and auxiliary power unit may impinge the lawn/landing zone surface at temperatures high enough to cause damage.

Nonetheless, earlier design challenges have reduced the amount of time available to complete government testing prior to the production decision. The program office has characterized its aggressive integrated test schedule as a risk factor it is tracking. To mitigate this risk, government pilots are participating in contractor-led testing and proactively engaging the contractor in discussions related to data gathered during these test events.

Production Readiness

The program anticipates completing an operational assessment of production representative aircraft capabilities before making the production decision. In addition, the program plans to demonstrate critical manufacturing processes on a pilot production line, prior to the start of production, to provide assurance that quality requirements will be met. Further, the program plans to determine production readiness through audits and inspections included in the Federal Aviation Administration's airworthiness certification process, which is used to determine whether an aircraft is safe to operate. According to program officials, by relying on the procedures built into the airworthiness process, they no longer needed to conduct their own separate production readiness review and the saving associated with this action will be reinvested into the program.

Other Program Issues

Prior challenges, including development-phase discoveries that required extensive design and structural analysis and part modifications and shortages, have affected the program. For example, some VH-92A-specific sub-system parts for the first development model aircraft have yet to be delivered. As a result, the contractor now plans to install the parts later than originally planned on this already flying aircraft to avoid test schedule delays. For subsequent aircraft, the contractor has identified acquisition of sheet metal (specific to the VH-92A helicopter) and machined parts as a risk area it is managing. Despite these challenges, the program office indicated they are still on track to meet their milestones. However, according to a November 2017 OSD assessment of the program, the production decision is 4 months beyond its objective date (driven by previous production delays, lagging training system development and the addition of post-operational assessment analysis and scoring tasks). Given this assessment, the program would have only two months of schedule flexibility remaining for its production decision milestone.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

Source: Huntington Ingalls Industries, Pascagoula, MS.

DDG 51 Arleigh Burke Class Destroyer, Flight III (DDG 51 Flight III)

The Navy's DDG 51 Flight III destroyer will be a multi-mission ship designed to operate against air, surface, and underwater threats. Compared to existing Flight IIA ships of the same class, the new Flight III ships will provide increased ballistic missile and area air defense capabilities to the fleet. Flight III's planned configuration changes include replacing the current SPY-1D(V) radar with the Air and Missile Defense Radar program's SPY-6 radar. The Navy planned to acquire 14 Flight III ships—beginning with DDG 125 and DDG 126—that will be constructed by two shipbuilders.

Program Essentials

Program office: Washington, DC

Prime contractors: Huntington Ingalls Incorporated and Bath Iron Works Corporation

Contract type: Fixed-price incentive (construction)

Next major milestone: Fabrication start for first Flight III ship (DDG 125) (May 2018)

Estimated Program Cost

(fiscal year 2018 dollars in millions)

Planned Quantities

Updated cost and quantity estimates not reflected here are available in the fiscal year 2019 President's Budget.

Current Status

The Navy continues to undertake Flight III detail design activities, which have included extensive changes to the ship's hull, mechanical, and electrical systems to incorporate the SPY-6 radar and restore weight and stability safety margins within the ship. Both Flight III shipbuilders completed zone design activities—three-dimensional modeling of the individual areas within the ship—by December 2017, before the start of lead ship construction. All four of Flight III's critical technologies are mature and undergoing testing. To help reduce technical risk, the Navy plans to field all but one of the critical technologies—the SPY-6 radar—on other ship classes before integration with Flight III.

A draft Test and Evaluation Master Plan for Flight III is under review within DOD. The Director, Operational Test and Evaluation (DOT&E) and the Navy are deliberating whether Flight III initial operational test and evaluation will include the use of a self-defense test ship equipped with the Aegis combat system and SPY-6 radar. The Navy currently does not plan to provide funding for this modified self-defense test ship, contending there are other means to validate performance. However, DOT&E reports that it will not be able to fully determine Flight III's defensive capabilities without it.

In June and September 2017, the Navy modified existing Flight IIA multiyear procurement contracts—contracts that allow the Navy to procure multiple years' worth of ships on a single contract action—to include construction of the first two Flight III ships, with the Flight III configuration upgrades incorporated. Huntington Ingalls plans to begin construction of DDG 125 in May 2018; Bath Iron Works will begin DDG 126 in April 2019. For later Flight III ships, Congress has authorized the Navy to enter into multiyear procurement contracts for up to 15 additional ships.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. Navy officials noted the DDG 51 program has successfully delivered 65 ships since program inception in 1985 and made awards for 77 ships to date. They said that Flight III design efforts are stable and on track, with planned completion prior to Flight III construction.

Source: U.S. Navy.

Guided Missile Frigate (FFG(X))

The Navy's new guided missile frigate program is intended to develop and deliver a small surface combatant with enhanced lethality and survivability as compared to the Littoral Combat Ship (LCS). The Navy expects FFG(X) to be an agile, multi-mission ship that provides local air defense, maximizes anti-surface and -submarine warfare capabilities, and delivers capability to protect and enable communications in hostile environments.

Program Essentials

Program office: Washington Navy Yard, DC

Prime contractor: TBD

Contract type: TBD

Next major milestone: Preliminary Design Review (June 2019)

Estimated Program Cost

(through fiscal year 2022 only; fiscal year 2018 dollars in millions)

Planned Quantities

Current Status

In May 2017, the Navy shifted away from its plan for a new frigate derived from minor modifications to an LCS design and now plans to select a new frigate design and shipbuilder through a full and open competition that is not limited to LCS derivatives. The program intends to leverage the proposed capabilities of the original frigate program and expand upon them to create a more lethal and survivable ship.

In fiscal year 2018, the FFG(X) program plans to focus on system specifications development and approval, acquisition program documentation needs, test strategy development, and combat management system integration. The program released a request for conceptual design proposals in November 2017 and plans to award multiple contracts in 2018 in an effort to reduce risk by maturing industry designs to meet FFG(X) capability needs.

Consistent with statute and knowledge-based practices, the Navy has scheduled a preliminary design review prior to a development start decision in February 2020. To support the development start decision, the program expects to complete an independent cost estimate, affordability and should-cost analyses, and an independent technical risk assessment. Although the number of planned frigates remains uncertain due to previous Secretary of Defense direction to cap the combined total of LCS and frigates at 40 ships, the program plans to award what the Navy refers to as a “block buy” contract for FFG(X) detail design and construction in September 2020. This block buy contract, which the Navy plans to award to a single shipbuilder, is intended to achieve more favorable pricing, but as planned, would require the Navy to commit to more than 1 year's worth of procurement in a single contract. If the Navy requests congressional authorization during 2019 for the planned fiscal year 2020 block buy, the Navy will lack key knowledge, such as an independent cost estimate, to support its request.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program stated that conceptual design allows the Navy to mature multiple designs and better understand cost and capability drivers across design options before a detail design and construction award, as well as inform final specifications that will achieve a best value solution.

Source: Computer Science Corp (CSC) pursuant to LX(R) Design Support Contract notional concept LX(R).

Amphibious Ship Replacement (LX(R))

The Navy's LX(R) program plans to build a new class of ships to replace existing amphibious ships, which the Navy uses to transport Marines and their equipment to distant operating areas and enable expeditionary operations ashore. The LX(R) will include a larger hull than the retiring ships, and will also be used for non-combat operations due to its storage space and ability to transfer people and supplies. Starting in fiscal year 2020, the Navy plans to procure 13 ships with delivery of the first LX(R) scheduled for 2026.

Program Essentials

Program office: Washington Navy Yard, DC

Prime contractors: Huntington Ingalls Industries and General Dynamics National Steel and Shipbuilding Company (NASSCO)

Contract types: Cost-plus-fixed-fee (early design)
Fixed-price incentive type (planned; detail design and construction)

Next major milestone: Detail design and construction contract award (March 2020)

Estimated Program Cost

(fiscal year 2018 dollars in millions)

Planned quantities

Current Status

According to LX(R) program officials, the Navy has undertaken an affordability review of the program prior to the planned solicitation of proposals for lead ship detail design and construction in June 2018. The Navy plans to base LX(R) on the existing design of San Antonio (LPD 17) class amphibious ships with modifications to reduce costs. Any design changes, however, must still meet the validated LX(R) performance requirements. LX(R) program officials further stated that the class will not introduce any new critical technologies in an effort to further decrease program costs.

The Navy has initiated a limited competition approach for LX(R), although the program's overall acquisition strategy is still in development. The Navy combined LX(R) early design efforts with acquisition activities for the next America Class Amphibious Assault Ship (LHA 8) and the John Lewis Class Fleet Replenishment Oilers (T-AO 205) to reportedly better sustain the naval shipbuilding industrial base. In 2016, the Navy awarded contracts to Huntington Ingalls and General Dynamics NASSCO for early LX(R) design activities. These contracts allotted 75 percent of the LX(R) contract design hours to Huntington Ingalls and the remainder to NASSCO. Also in 2016, Congress appropriated $250 million in advanced procurement funds—three years earlier than planned—which would have accelerated lead ship construction, but in 2017 it rescinded $236 million of this funding. The National Defense Authorization Act for Fiscal Year 2017 authorized the Navy to enter into a contract for the design and construction of the LX(R) or LPD-29 using shipbuilding and conversion funds. Further, the Navy continues to deliberate on which phase LX(R) will enter the acquisition cycle. Although a new program, program officials have proposed that LX(R) entry occur at full-rate production—a significant departure from a typical new shipbuilding acquisition—but Navy leadership has yet to approve this approach.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

Source: Jeff Hobrath, Chief, USN (Ret) President, Naval Tees, LLC.

MQ-25 Unmanned Aircraft System (MQ-25 Stingray)

The Navy's MQ-25 will be a catapult-launched unmanned aircraft system (UAS) operating from aircraft carriers. When complete, it is primarily intended to provide a refueling capability for the carrier air wing and a secondary intelligence, surveillance, and reconnaissance (ISR) capability. The system is made up of an aircraft segment, a control station segment, and a carrier modification segment. It is the outcome of a restructure of the former Unmanned Carrier-Launched Airborne Surveillance and Strike (UCLASS) program.

Program Essentials

Program office: Patuxent River, MD

Prime contractor: TBD

Contract type: Fixed-price incentive

Next major milestone: Development start (August 2018)

Estimated Program Cost

(fiscal years 2016-2022; fiscal year 2018 dollars in millions)

Planned Quantities

Current Status

The Navy plans to award an MQ-25 development contract in the fourth quarter of fiscal year 2018. The Navy has yet to identify any critical technologies for the MQ-25, but has asked potential contractors to identify any critical technologies they plan to use, and the maturity of those technologies, within their proposals. The Navy does not plan to conduct a system-level preliminary design review before starting MQ-25 development. Instead, the Navy plans to rely on knowledge gained through previously conducted reviews under the UCLASS program and risk reduction studies and analyses conducted by the four companies that competed for the UCLASS development contract.

The MQ-25 program resulted from DOD's February 2016 review of its airborne ISR portfolio. Based on this review, DOD directed the Navy to restructure the UCLASS program to create the Carrier-Based Aerial Refueling System, which DOD subsequently designated the MQ-25. As compared to the UCLASS program's focus on intelligence, surveillance and reconnaissance capabilities, the MQ-25 program's primary requirements are carrier suitability and air refueling. From September to October 2016, the Navy awarded four contracts with a combined total value of $250 million to the four companies that previously competed for the UCLASS development contract. These contracts required each company to evaluate potential MQ-25 performance requirements and technical risks involving integration and deck handling, among other things.

In July 2017, the Joint Requirements Oversight Council approved the MQ-25 requirements document that was informed by the contractors' efforts. According to Navy officials, this document reflects an MQ-25 aerial refueling capability that far exceeds the refuel capacity currently provided by F/A-18E/F Super Hornet aircraft. Further, Navy officials expect MQ-25 will reduce the need for F/A-18E/F aircraft to perform refueling missions, which will increase their availability for strike fighter missions and preserve their service life.

Program Office Comments

The program office provided technical comments, which we incorporated where appropriate.

Source: U. S. Navy

P-8A Increment 3 (P-8A Inc 3)

The Navy's P-8A Increment 3 is intended to provide enhanced capabilities to the P-8A aircraft in four sets of improvements. The first two sets include communications, radar, and weapons upgrades, which will be incorporated into the existing P-8A architecture. The second two sets will establish a new open systems architecture, add improvements to the combat system's ability to process and display classified information, and enhance the P-8A's search, detection, and targeting capabilities. We assessed Increment 3 separately from the P-8A baseline program, which we reviewed in prior reports.

Program Essentials

Program office: Patuxent River, MD

Prime contractor: Various

Contract type: Various (development)

Next major milestone: Increment 3 design review (July to September 2019)

Estimated Increment 3 Cost

(FY 2018 dollars in millions)

Planned procurement quantities

Note: All aircraft, including previously delivered aircraft, will be retrofitted with Inc 3 capabilities.

Current Status

In March 2016, the Under Secretary of Defense for Acquisition, Technology and Logistics approved a revised P-8A acquisition strategy, which made Increment 3 part of the baseline program. Increment 3 capabilities will be developed and delivered as a series of engineering change proposals, or design changes. The goal of these efforts is to deliver improved capabilities and implement an open architecture that will introduce competition, increase the government's role in developing future upgrades, and eventually lower costs. Increment 3 initial operating capability is planned for fiscal year 2024 and these capabilities are to be incorporated into all P-8A aircraft by 2034. Program officials said that the program received $70 million less in development funds than requested for fiscal year 2017, and that this delayed the planned introduction of the last sets of capabilities by one year.

One of the most significant developments in Increment 3 is the upgrade of the P-8A combat system, which is part of engineering change proposal 6. This set of capabilities will require the integration of new hardware and software, including hardware changes to the aircraft. According to program officials, these capabilities are all based on mature technologies. The combat system upgrade includes an application-based open system architecture that will allow the program to compete the development and integration of future capabilities. The program used full and open competition to award two contracts for the design of the architecture upgrade prototype. The program will choose the best parts of each design and act as the lead integrator for the combat system. The program plans to complete the development and integration of the combat system into the aircraft in fiscal year 2022. The last upgrade in Increment 3 is dependent on combat system hardware updates.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office also noted that the first set of Increment 3 upgrades has been delivered and the next set is in testing. It also stated that reductions to development funding in fiscal years 2017 and 2018 have led to a program restructuring and additional delays in fielding the remaining upgrades, including anti-submarine warfare improvements.

Source: U.S. Navy photo courtesy of Huntington Ingalls Industries.

SSN 774 Virginia Class Submarine Block V (SSN 774 Block V)

The SSN 774 Virginia Class Submarine is a nuclear-powered attack submarine with multi-mission capability and enhanced features for special operations forces, and command, control, communication, and intelligence capability. The Navy has implemented major upgrades to the class through new blocks. The most recent block, Block V, will include enhanced undersea acoustic improvements (called acoustic superiority) and increased strike capacity from 12 to 40 Tomahawk cruise missiles with the insertion of a new mid-body section.

Program Essentials

Program office: Washington, DC

Prime contractor (planned): General Dynamics Electric Boat

Contract type (planned): Fixed-price incentive (detail design and construction)

Next major milestone: Block V contract award (early fiscal year 2019)

Estimated Program Cost

(fiscal year 2018 dollars in millions)

Planned Quantities

Note: Cost estimates include fiscal years 2019-2022, which are specific to Block V. The Navy has not yet determined funding needs beyond fiscal year 2022. The Navy allocated $496 million in prior development funds for the block V payload module, which are not reflected here. Quantities include all planned Block V submarines, which span fiscal years 2019-2023.

Current Status

In early 2019, the Navy plans to award a multi-billion dollar, multi-year procurement contract for construction of 10 Block V submarines. Under the Navy's plan, all Block V ships will include the acoustic superiority improvements, while the new mid-body section (called the Virginia Payload Module) will be added starting with the second Block V submarine. According to program officials, the design of Block V submarines will differ from Block IV submarines by approximately 20 percent. Of this redesigned 20 percent, the program office considers 70 percent to constitute major changes. The program plans to complete basic and functional designs by lead ship construction start, which would be consistent with GAO-identified best practices. However, the program is currently behind schedule in its design efforts for the new payload module. While the program office has identified plans to recover from these design delays, success will hinge on the Navy and shipbuilders' ability to sufficiently staff remaining Block V design workload correspondent with ongoing design efforts for the new Columbia class ballistic missile submarine. Similarly, construction will require the shipyards to manage the demands from both programs since Columbia class starts construction in fiscal year 2021.

According to the Navy's justification materials for the planned multi-year procurement, the Block V submarine unit cost totals approximately $48 million more in constant year 2018 dollars than the unit cost for Block IV submarines. The Block V effort is under the SSN 774 major defense acquisition program, which was downgraded in 2015 by the Office of the Secretary of Defense (OSD) to be under Navy—and not OSD-level—program oversight. SSN 774 had already completed its required milestone reviews well before the introduction of Block V but, according to program officials, the program continues to conduct regular Navy-level oversight reviews. The Navy also is not planning to develop an independent cost estimate for the Block V prior to awarding the multi-billion dollar contract, but has developed a program cost assessment and holds cost-related meetings with OSD.

Program Office Comments

In commenting on a draft of this assesssment, the program office provided technical comments, which we incorporated where appropriate.

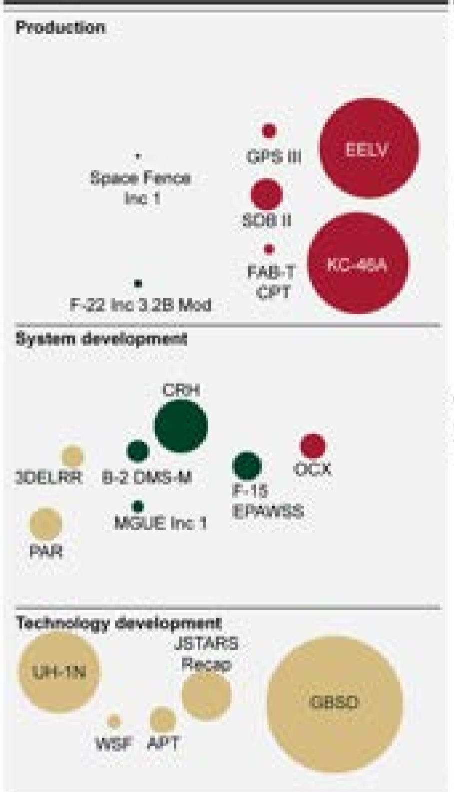
Air Force Assessments

We completed individual assessments on 20 of the Air Force's 40 current and future major defense acquisition programs. Of these 20 programs, 14 are in either system development or early production while 6 are future programs that DOD expects to enter system development in the next few years. We found the Air Force currently estimates a need of $155 billion to complete the acquisition of these 20 programs. We also compared these programs' first full estimates of cost and schedule with their current estimates and found that:

- Net cost growth totals $32.6 billion, almost all of which occurred in the past 5 years and is attributable to the Evolved Expendable Launch Vehicle (EELV) program, and
- Program schedule delays average approximately 13 months.

Only two of the 20 programs—EELV and Space Fence Inc 1—completed all activities associated with the applicable knowledge-based best practices we assess, although these activities were not fully complete at the time the knowledge points were reached.

Acquisition Phase and Size of the 19 Programs Assessed

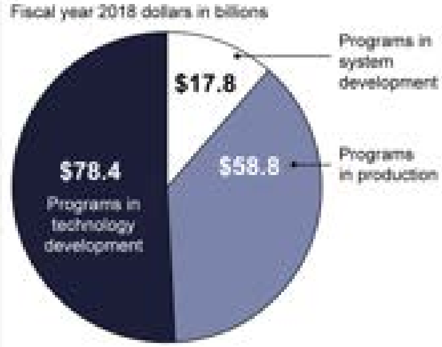


● Cost growth of more than 15 percent and/or schedule delays of more than 6 months
● Cost growth of 15 percent or less and schedule delays of 6 months or less
● No first full estimate available

Note: One system did not provide sufficient information to be included in our analysis. Bubble size is based on each program's currently estimated future funding needed.

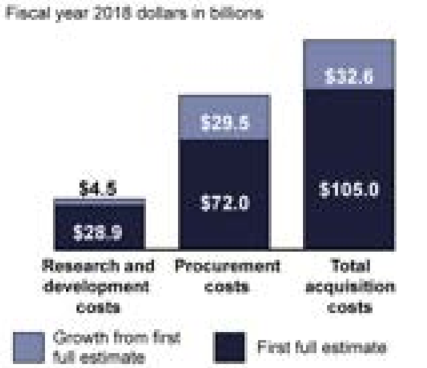
Currently Estimated Acquisition Costs for the 19 Programs Assessed

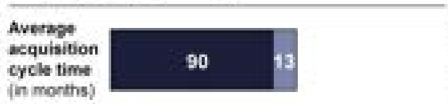
Fiscal year 2018 dollars in billions



Cost and Schedule Growth on 13 Programs in the Current Portfolio

Fiscal year 2018 dollars in billions





Note: For acquisition cycle time only 8 programs were assessed as not all programs contained sufficient information within their first full estimates to determine acquisition cycle time. In addition to research and development and procurement costs, total acquisition cost includes acquisition related operation and maintenance and system-specific military construction costs.

Summary of Knowledge Attained to Date for Programs Beyond System Development Start

Program common name	Knowledge Point (KP) 1 Resources and requirements match: At KP1	Knowledge Point (KP) 1: Current Status	Knowledge Point 2 Product design is stable: At KP2	Knowledge Point 2: Current Status	Knowledge Point 3 Manufacturing processes are mature: At KP3	Knowledge Point 3: Current Status
B-2 DMS	○	○	KP 2 in future		KP 3 in future	
CRH	○	○	○	○	KP 3 in future	
EELV	- - -	●	- - -	- - -	- - -	- - -
F-15 EPAWSS	○	○	○	○	KP 3 in future	
F-22 Inc 3.2B Mod	○	●	○	●	○	○
FAB-T CPT	- - -	○	○	●	○	○
GPS III	○	●	○	●	○	○
KC-46A	○	●	○	●	○	○
MGUE Inc 1	○	○	N/A		N/A	
GPS OCX	○	○	N/A		KP 3 in future	
SDB II	○	●	○	●	○	○
Space Fence Inc 1	○	●	○	●	N/A	
3DELRR	○	○	KP 2 in future		KP 3 in future	

● All applicable knowledge practices completed
○ One or more applicable knowledge practices were not completed
N/A Knowledge practice is not applicable
- - - Information not available for all applicable knowledge practices

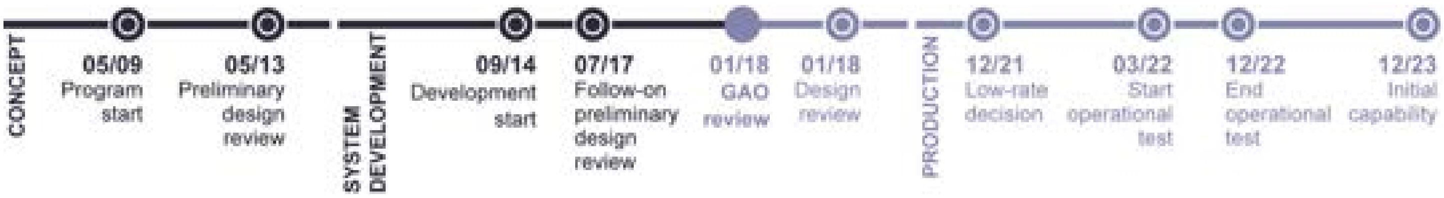
Source: GAO analysis of DOD data. | GAO-18-360SP

Air Force Program Assessments

Source: U.S. Air Force

Three-Dimensional Expeditionary Long-Range Radar (3DELRR)

The Air Force's 3DELRR is being developed as a long-range, ground-based sensor for detecting, identifying, tracking, and reporting aerial targets, including highly maneuverable and low observable targets. The system intends to provide real-time data and support a range of operations in all types of weather and terrain. It will replace the Air Force's AN/TPS-75 radar system, which has reached the end of its planned service life and is becoming more costly to maintain.



Program Essentials

Program office: Hanscom Air Force Base, MA

Prime contractor: Raytheon

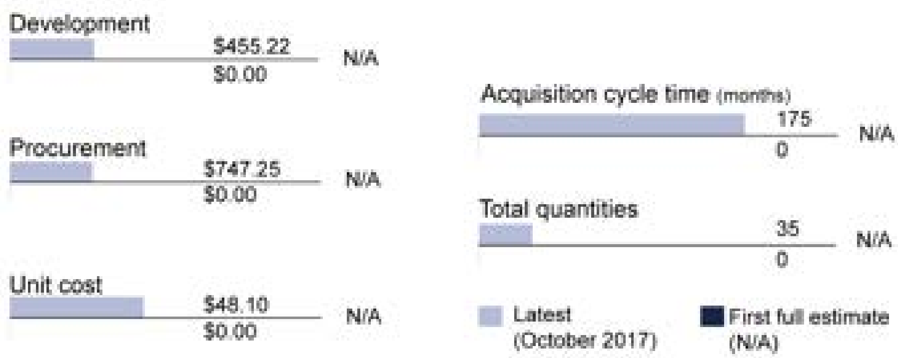
Contract type: Fixed-price incentive/firm-fixed-price (development)

Next major milestone: Low-rate initial production decision (TBD)

Program Performance

(Charts not to scale)

(fiscal year 2018, dollars in millions)



Total quantities comprise 3 development quantities and 32 procurement quantities. As of January 2018, the Air Force has yet to approve an acquisition program baseline, which would identify a first full estimate, for 3DELRR.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	NA	NA
• Test a system-level integrated prototype	NA	NA
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	NA	NA
• Demonstrate critical processes on a pilot production line	NA	NA
• Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

3DELRR Program

Technology Maturity

The 3DELRR program entered system development in October 2014 with its six critical technologies approaching maturity, and their maturity remains unchanged. Shortly after the program entered system development, the Air Force suspended performance on the development contract awarded to Raytheon after Lockheed Martin and Northrop Grumman filed bid protests. In January 2015, GAO dismissed the protests when the Air Force agreed to take corrective action to address the issues raised. Legal action continued in federal courts and before GAO, and the program ultimately re-entered the source selection phase and awarded a $52.7 million develoment and production contract to Raytheon in May 2017. Program officials stated that the critical technologies would be proven to work in their final forms and under expected conditions during developmental tests, which are scheduled to start in April 2020.

Design Stability

In January 2018, the 3DELRR program held its critical design review. At the time of our review, the program was in the process of finalizing the results, which precluded us from an assessment of design stability. The program office and contractor had delayed the critical design review from October 2017 to January 2018, in part due to a lack of technical readiness, which was assessed as part of a July 2017 DOD system-level review.

In July 2017, DOD's systems engineering office conducted a system-level technical review of the 3DELRR program as part of the program's follow-on preliminary design review to evaluate the contractor's design changes since the preliminary design review in May 2013. After the preliminary design review, the Air Force made trade-offs between affordability and performance of the 3DELRR system, which resulted in revisions to the technical requirements. For example, the Air Force reduced the required average time between critical failures, reduced the altitude the radar needs to survey, and increased the amount of time needed for the radar to scan an area. The contractor also revised its proposed 3DELRR design to reduce costs and improve producibility. However, DOD found that the contractor's revised design, which included a reduced number of transmit/receive and receive-only modules, may not meet the program's key performance parameters related to detection range for certain targets and operational availability. DOD recommended that the program office and contractor continue to work on the proposed design to minimize technical risks. In response, 3DELRR program officials delayed the critical design review to January 2018.

DOD's systems engineering office also noted risks with the contractor's software development efforts. Although contract performance did not occur from 2014 through 2017 while the legal action before the courts and GAO was being resolved, the contractor continued radar software development efforts using its own resources. During the July 2017 follow-on preliminary design review, the contractor stated that it did not plan to conduct additional software development for the program. According to the contractor, it had conducted this software development as part of its independent research and development efforts. The contractor further stated that, under the terms of its contract, any further software efforts would be related to correction of deficiencies found during integration and test. However, DOD determined that the scope of this effort could be underestimated because the program office did not have well-defined software integration and test metrics. DOD further noted that if the program does not achieve the predicted software reuse and commercial-off-the-shelf utilization during design and integration, then software development may require additional time, which would delay the program's schedule.

Other Program Issues

Although the program entered system development in October 2014, the award of the initial system development contract was the subject of legal action, and work under the subsequent system development and production contract did not begin until two and a half years later. Program officials explained that they could not prepare an acquisition program baseline until they reviewed the contractor's integrated master schedule, which they received in November 2017, and results from the July 2017 follow-on preliminary design review report.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. Program officials stated that they anticipate completing the acquisition program baseline in the second quarter of fiscal year 2018.

Source: U.S. Air Force.

B-2 Defensive Management System Modernization (B-2 DMS-M)

The Air Force's B-2 DMS-M program plans to upgrade the aircraft's 1980s-era analog defensive management system to a digital capability. This system detects and locates enemy radar systems to provide threat warnings and avoidance information. This upgrade is expected to improve the system's frequency coverage and sensitivity, update pilot displays, and enhance in-flight rerouting capabilities. It will improve the reliability and maintainability of the DMS system and the B-2's ability to be ready.

Program Essentials

Program office: Wright-Patterson Air Force Base, OH

Prime contractor: Northrop Grumman

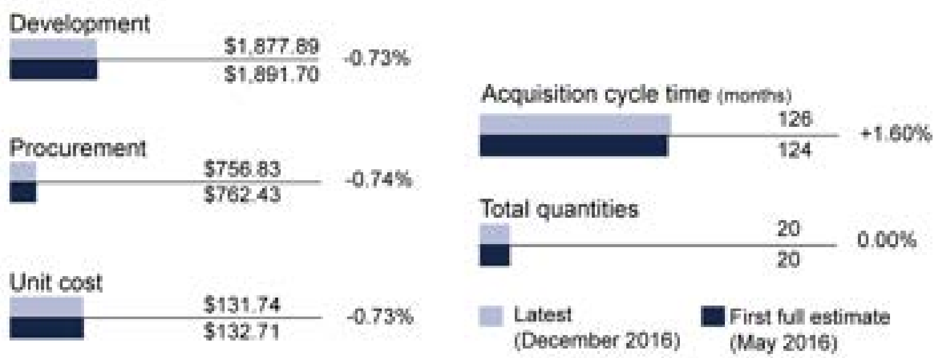
Contract type: Firm-fixed-price (development)

Next major milestone: Design Review (August 2018)

Program Performance

(Charts not to scale)

(fiscal year 2018 dollars in millions)



Total quantities comprise 4 development quantities and 16 procurement quantities.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	●	○
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	NA	NA
• Test a system-level integrated prototype	NA	NA
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	NA	NA
• Demonstrate critical processes on a pilot production line	NA	NA
• Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

B-2 DMS-M Program

Technology Maturity

The program entered system development in March 2016 with four critical technologies approaching maturity. Since then, Northrop Grumman proposed, and the Air Force accepted, an alternative system that provides additional capabilities and has been tested on another program. The alternative system has the same four critical technologies. Because major subsystems are being leveraged from existing systems, the program office assesses three of the four critical technologies as mature. One critical technology, band 2 (previously designated band 1) apertures, continues to approach maturity.

Design Stability

The Air Force's decision to pursue an alternative system has led to some delays. For example, although the program held a preliminary design review before entering system development, the program plans to complete a second preliminary design review (PDR) in February 2018 and the critical design review is now scheduled for August 2018. Based on the need for a new PDR, we have updated our knowledge table to reflect this change as compared to what we presented in our 2017 assessment. As of mid-January 2018 the contractor has completed 444 of 853 (52 percent) of the program's total drawings. Consistent with acquisition best practices, the program plans to release 100 percent of its design drawings by the critical design review. However, the program will not have tested a system-level integrated prototype before the critical design review, which could present risks for design changes when system-level integration testing takes place.

Software development, a critical factor for achieving required B-2 DMS-M capabilities, poses additional integration risks. The program requires certification of software block 7.1 functionality to support developmental flight testing. According to program officials, the contractor is behind schedule with software version PD 7.1 development. Their development team has not been able to achieve required staff increases or efficiencies needed in software development. Failure to certify software version PD 7.1 with full functionality by June 2019 could delay flight testing and most likely the low-rate production decision, planned for June 2020. Similar to other B-2 programs, the B-2 DMS-M program plans to rely on a single flight test aircraft to support the entire 3-year developmental and operational test program adding to the risks associated with its already aggressive schedule. The program office is working with the contractor to mitigate schedule risks, such as increasing the number of software developers and expanded overtime for existing staff.

Other Program Issues

The program office reports that, in May 2017, as a result of the alternative system approach and to mitigate some schedule risk, the program office and contractor agreed to an undefinitized contract action that changed the development contract type from a cost-type to firm-fixed-price effort. The program office stated that the undefinitized contract action included a not-to-exceed amount of $741 million until the contract scope and cost could be definitized, which was originally planned for July 2017. Issues in receiving a complete proposal have delayed definitization. The program office reports approximately 30 percent of the $741 million not-to-exceed amount has been obligated. At the time of this report, the Air Force has not finalized a revised service cost position to reflect the alternative approach and change in contract type, but efforts are under way. Preliminary results did indicate a notable increase in total program costs driven by flight test schedule risks and production costs.

Other program risk factors include: (1) the addition of flight tests needed for added capabilities could compound schedule risk; (2) the reliability and maintainability effects are unknown; (3) the subsystem's performance is not fully understood; (4) the suppliers' ability to deliver parts in time for testing; and (5) the ability to maintain cost and schedule given the fixed-priced and technical environments.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office also stated that development of the alternative system is not executable within the existing Air Force budget, but that the Air Force is currently working on a cost-versus-capability trade analysis of the program. The service cost position for the program depends on results of the trade analysis. According to the program office, to date the contractor has not achieved the efficiency necessary for timely completion of software, putting the scheduled certification of block PD 7.1 by June 2019 at risk. However, the program office said that the contractor is taking actions, which the program is closely monitoring, to preserve schedule. Additionally, the program stated that it has implemented a 5-release software development approach to address system-level integration prior to the critical design review. It expects three of those releases to conclude before the review.

Source: © 2017 Sikorsky A Lockheed Martin Company. Used with permission for supporting of the Air Force's Combat Rescue Helicopter Program and Combat Rescue Helicopter associated efforts.

Combat Rescue Helicopter (CRH)

The Air Force's Combat Rescue Helicopter (CRH) program replaces the Air Force's aging HH-60G Pave Hawk rescue helicopter fleet with 112 new air vehicles, training systems, and support for increased personnel recovery capability. CRH uses a derivative of the operational UH-60M helicopter. Planned modifications to the existing design include a new mission computer and software, a higher capacity electrical system, larger capacity main fuel tanks, armor for crew protection, gun mount system and situational awareness enhancements.

Program Essentials

Program office: Wright-Patterson Air Force Base, OH

Prime contractor: Sikorsky Aircraft Corporation

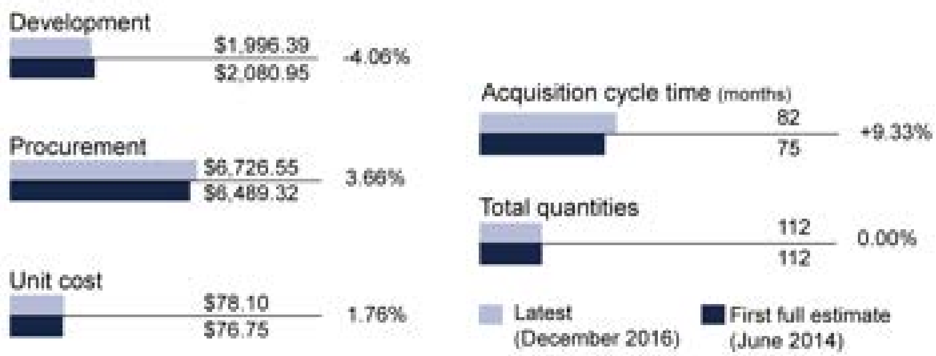
Contract type: Fixed-price incentive/firm-fixed-price (development)

Next major milestone: Low-rate initial production (July 2019)

Program Performance

(Charts not to scale)

(fiscal year 2018 dollars in millions)



Total quantities comprise 9 development quantities and 103 procurement quantities.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	○	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	●	●
• Test a system-level integrated prototype	○	○
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	NA	NA
• Demonstrate critical processes on a pilot production line	NA	NA
• Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

CRH Program

Technology Maturity and Design Stability

CRH's one critical technology—a radar warning receiver—is approaching maturity, and the program reports that it has released 99 percent of planned design drawings, which constitutes a stable design. However, as the program continues to mature the radar warning receiver—and as that technology evolves into a final form, fit, and function—the program may need to revise its design drawings to accommodate necessary changes.

CRH began system development in 2014 without any reported critical technologies. Instead, the program planned to rely on mature technologies in its design, and obtained a waiver from technology maturity requirements. However, in 2016 the Air Force identified the radar warning receiver as a critical technology and assessed it as immature. The program now expects the receiver to be fully mature by the time integrated laboratory testing occurs in April 2018.

Approximately 74 percent of the CRH design is based on the operationally fielded UH-60M helicopter. Because of these similarities, the CRH program has yet to test a system-level integrated prototype to demonstrate its design, although best practices criteria states that such a prototype should be tested by a program's critical design review. Instead, CRH program officials report that, in February 2017, they began lab-based prototype tests using a partial CRH system. However, these tests will not fully demonstrate certain CRH subsystems and software, which continue to pose technical risk in the program.

In May 2017, the CRH program completed its system-level critical design review with 94 percent of its expected drawings released to manufacturing. Since that review, the program has increased these releases to total 99 percent of expected CRH drawings. The program continues to track several technical risks related to radar warning receiver integration, helicopter weight, and the gun mount system that could affect design stability.

Production Readiness

In July 2019, the CRH program office has scheduled a decision on when to start production. Ahead of that decision, the program office expects to demonstrate statistical control of its critical manufacturing processes and to test a production representative prototype—actions that are consistent with best practices. Although program officials could not estimate how much of the CRH's performance capability is enabled by software, the program's overall software development effort will not complete until 2020. Program officials stressed that any software work taking place after the first quarter of 2019 will primarily be to address anomalies discovered during flight testing. They further stated that this strategy will reduce the likelihood of changes after production start, which we have previously found can prove costly and disruptive to flight test schedules.

Other Program Issues

Program officials expect to meet CRH affordability requirements for average unit cost, but expect to exceed the program's baseline cost estimate for military construction by $10 million due to increased trainer facilities requirements. In addition, program officials state this amount will further fluctuate due to DOD pricing guide rate changes. The CRH program requested procurement funding in fiscal year 2019 to produce the first 10 production-model helicopters. However, the program's ability to oversee this and current contractor activities is currently impaired as program officials stated that they have been unable to fill approximately 30 percent of program office engineering positions. According to program officials, this shortfall has resulted from a lack of qualified applicants and includes engineering positions related to communications, navigation, and software.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. Program officials also noted they have generated new cost estimates that are reflected in the approved acquisition program baseline.

Source: United Launch Alliance and SpaceX.

Evolved Expendable Launch Vehicle (EELV)

The EELV program provides spacelift support for DOD, national security agencies, and other government missions. Currently, United Launch Alliance (ULA) and Space Exploration Technologies Corporation (SpaceX) are the only certified providers of launch services. ULA provides launch services for EELV using two families of launch vehicles, Atlas V and Delta IV. SpaceX provides launch services using its Falcon 9. We assessed both ULA's and SpaceX's vehicles.

Program Essentials

Program office: El Segundo, CA

Prime contractors: United Launch Alliance and Space Exploration Technologies

Contract types: Cost-plus-incentive-fee/cost-plus-fixed-fee/firm-fixed-price (launch procurements, United Launch Alliance)

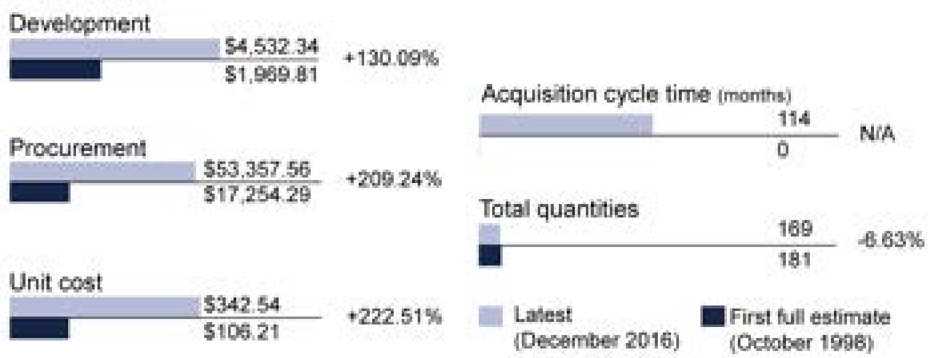
Firm-fixed-price (launch procurements, Space Exploration Technologies)

Next major milestone: Not applicable

Program Performance

(Charts not to scale)

(fiscal year 2018 dollars in millions)



Total quantities comprise 1 development quantity and 168 procurement quantities.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	…	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	…	●
• Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	…	…
• Test a system-level integrated prototype	…	…
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	…	…
• Demonstrate critical processes on a pilot production line	…	…
• Test a production-representative prototype in its intended environment	…	…

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

EELV Program

Technology Maturity, Design Stability, and Production Readiness

All but one (14 of 15) of ULA's launch vehicle variants—which are based on payload fairing size and number of strap-on solid rocket boosters used—and two variants of SpaceX's Falcon 9 have flown at least once, demonstrating technology maturity. For design stability and production readiness, the program assesses launch vehicles using Aerospace Corporation's "3/7 reliability rule." Once a variant is launched successfully three times, its design can be considered stable and mature. Similarly, if a variant is successfully launched seven times, both the design and production process can be considered stable and mature.

Twelve of ULA's variants have achieved design stability, and four have reached both design stability and production readiness. Some variants are used infrequently and may never reach design stability or production readiness. The Falcon 9 v1.1 has achieved both design stability and production readiness, but did not meet Air Force National Security Space reliability or performance requirements, according to the program office. A new variant—the Falcon 9 Upgrade, which SpaceX intends to use going forward for EELV launch service competitions—first flew in December 2015 and was certified for EELV launches in January 2016. SpaceX conducted an initial demonstration flight of its new variant—the Falcon Heavy—in February 2018. New vehicles, or variants that introduce changes to the original design, can pose increased cost and schedule risks until they are proven through multiple successful flights.

Other Program Issues

The program is pursuing an acquisition approach to help ensure DOD's access to space and maintain multiple launch providers. One of ULA's current launch vehicles, Atlas V, uses the RD-180 engine for propulsion, which is designed and manufactured in Russia. The National Defense Authorization Act (NDAA) for Fiscal Year 2015, as amended, prohibited, with certain exceptions, the award or renewal of a contract for the procurement of property or services for National Security Space launch activities under the EELV program if such contract carries out such activities using rocket engines designed or manufactured in the Russian Federation.

In addition, a provision in the FY18 NDAA restricts any obligation or expenditure to carry out the EELV program using funds authorized under the FY18 NDAA or otherwise made available for FY18 for research, development, test, and evaluation to development of the following: a domestic rocket propulsion system to replace non-allied space launch engines; integration of the domestic propulsion system with an existing or planned launch vehicle; and capabilities necessary to enable existing or planned commercially available launch vehicles or infrastructure that are primarily for National Security Space missions to meet statutory assured access to space requirements.

The Air Force stated that to avoid a gap in launch capability for National Security Space launch missions, the Air Force awarded agreements in early 2016, utilizing DOD's "other transaction" authority, for rocket propulsion system development. According to the program office, the awardees are on track for propulsion systems to be qualified and ready for production by 2019 to support the program's requirement for assured access to space.

Furthermore, in October 2017, the EELV program office released a Launch Service Agreement request for proposals and by summer 2018 plans to award at least three other transaction agreements to develop launch vehicle prototypes capable of meeting national security requirements. The Air Force is requesting proposals for shared public-private investment in the launch systems. According to the program, in 2019, it plans to award contracts to two of the launch providers for a combined total of approximately 25 launches to occur from 2022 through 2026.

Implementing a strategy to support multiple providers may prove challenging as the program stated that it expects demand for national security launches to decline from about eight per year to five per year from 2022 to 2026 and providers will have to rely more heavily on conducting civil government and commercial launches, which have historically been difficult to predict. However, the Air Force recently released a request for information to gather detailed data from potential launch providers on the number of launches they require to close their business cases.

The Air Force may face challenges in supporting additional launches of its heaviest satellites because of parts obsolescence issues and the challenges for commercial-based systems to meet the National Security Space reliability and performance requirements for these missions. The Air Force intends to procure three Delta IV Heavy-launch vehicles to support near-term national security launch requirements. However, while ULA has enough launch vehicle components to support these missions, if additional missions are required and other, new launch vehicles are not available as planned or projected, some new Delta IV Heavy components will have to be designed and manufactured to replace those that are no longer available from suppliers. The use of such components could involve substantial testing, certification, and additional cost.

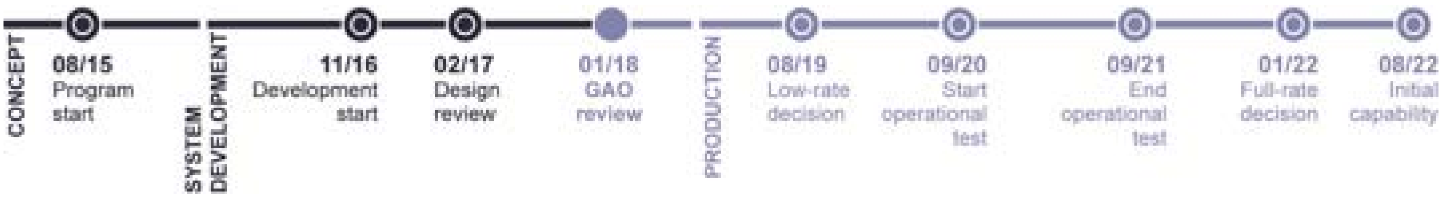
Program Office Comments

The program office provided technical comments, which we incorporated where appropriate.

Source: U.S. Air Force.

F-15 Eagle Passive Active Warning Survivability System (F-15 EPAWSS)

The Air Force's F-15 EPAWSS is a modernization program to upgrade the electronic warfare (EW) system used on F-15 aircraft. EPAWSS is leveraging both hardware and software currently in use on other military aircraft in an effort to improve the F-15's ability to identify and neutralize advanced air and ground threat systems. Using an incremental acquisition approach, EPAWSS Increment 1 will replace the F-15's legacy EW system and a proposed Increment 2 will provide a new towed decoy and associated countermeasures. We assessed Increment 1.



Program Essentials

Program office: Wright-Patterson Air Force Base, OH

Prime contractor: Boeing

Contract types: Cost-plus-incentive-fee/cost-plus-fixed-fee (technology maturation and risk reduction) Cost-plus-incentive-fee/cost-plus-fixed-fee/firm-fixed-price (development)

Next major milestone: Low-rate initial production (August 2019)

Program Performance

(Charts not to scale)

(fiscal year 2018 dollars in millions)

Latest total quantities comprise 4 development quantities and 217 procurement quantities. Four units included in the procurement quantity will start out as development funded test articles and then be converted to a production configuration once testing is complete.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	○	●
• Test a system-level integrated prototype	○	○
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	NA	NA
• Demonstrate critical processes on a pilot production line	NA	NA
• Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

F-15 EPAWSS Program

Technology Maturity

EPAWSS entered system development in November 2016 with its four critical technologies approaching full maturity following demonstration with existing hardware in a high-fidelity lab environment. The Air Force plans to lab test new EPAWSS hardware containing the four technologies for the first time in April 2018 to demonstrate functionality. However, the Air Force does not plan to fully mature EPAWSS critical technologies to final form, fit, and function and demonstrate them in a realistic environment until the start of F-15 flight testing in November 2018. This approach introduces risk of flight test delays if technologies do not mature as expected and is inconsistent with best practices.

Design Stability

The EPAWSS program completed its system-level critical design review (CDR) in February 2017 having released a total of 87 percent of EPAWSS drawings to manufacturing. This total falls just short of the 90 percent recommended at CDR to demonstrate design stability. Specifically, the program had released 99 percent of EPAWSS hardware drawings, but only 83 percent of required F-15 airframe drawings, at CDR. The program now reports release of a combined 99 percent of drawings, which constitutes a stable design. The stability could be at risk, however, as the program continues to fully mature its critical technologies.

In addition, the program did not complete integration lab testing of a full-up system prototype before CDR, which best practices recommend. This testing is now scheduled for April 2018. EPAWSS test aircraft modifications begin in December 2017 without the benefit of this prototype testing, but program officials claim the risk of rework is avoidable since the actual EPAWSS hardware will not be installed until July 2018, and they expect that any changes to EPAWSS will occur at a subcomponent level with no airframe installation effects.

The program currently identifies EPAWSS performance in a real-world radio frequency signal environment and availability of needed test resources as top development risks. To mitigate these risks, the program plans to complete a series of high-fidelity lab tests to demonstrate near full performance of EPAWSS before the start of flight testing. The program has also been addressing test resource capability gaps as well as finding other testing efficiencies. The program is also closely tracking EPAWSS software development as it reuses a large amount of code from three different contractors, which must be integrated with the EPAWSS hardware.

Production Readiness

The Air Force has scheduled an EPAWSS production start decision for August 2019 with the program currently expecting to demonstrate manufacturing processes on a pilot production line and test a fully configured production-representative prototype before that milestone. However, some EPAWSS software development and flight testing will take place after production start, introducing risk of design changes to address performance issues discovered late in testing. The Air Force is also separately managing several other F-15 aircraft modification efforts that must be ready before EPAWSS testing can be completed and fielding begun.

Other Program Issues

The Air Force initially funded EPAWSS Increment 1 development for both the F-15C and F-15E, but now plans to procure EPAWSS for only the F-15E, resulting in a quantity decrease of 192 aircraft and a unit cost increase that is under statutory reporting thresholds and leaves the program's affordability caps unaffected. The Air Force could decide to add the F-15C quantities back into the program should procurement funding become available, since Increment 1 development for that aircraft continues. The Air Force does not plan to fund EPAWSS Increment 2 development until fiscal year 2021 and has yet to complete many program management and design decisions related to that increment.

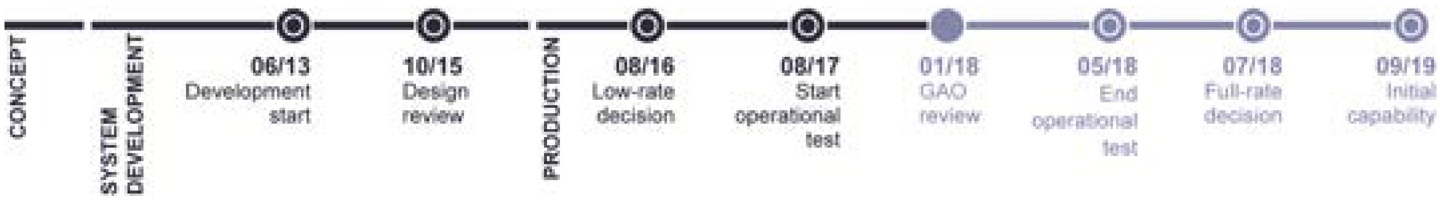
Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office stated that the current F-15C/E electronic warfare suite is functionally obsolete. It also noted that today's emerging threat environment is driving the EPAWSS program to execute an aggressive schedule in order to address that environment. According to the program, it has leveraged designs from other developmental systems to mitigate risks. It also stated that it successfully accomplished critical technology prototype tests in a lab prior to the critical design review. The program anticipates that tests planned for summer 2018, prior to first flight, will demonstrate the full system's ability to detect and identify threats in a combat representative environment. Additionally, the program reported that aircraft modifications are on track to support a flight-test readiness review in November 2018

F-22 Increment 3.2B Modernization (F-22 Inc 3.2B Mod)

Source: U.S. Air Force.

The Air Force's F-22 Raptor is a stealthy air-to-air and air-to-ground fighter/attack aircraft. The Air Force established the F-22 modernization and improvement program in 2003 to add enhanced air-to-ground, information warfare, reconnaissance, and other capabilities, and to improve the reliability and maintainability of the aircraft. The Air Force initially managed Increment 3.2B, the fourth increment of the modernization program, as part of the F-22 baseline program, but now manages this effort as a separate major defense acquisition program.



Program Essentials

Program office: Wright-Patterson Air Force Base, OH

Prime contractor: Lockheed Martin

Contract type: Cost-plus-incentive-fee/cost-plus-fixed-fee (development) Cost-plus-fixed-fee/Firm-fixed-price (production)

Next major milestone: Full rate production (July 2018)

Program Performance

(Charts not to scale)

(fiscal year 2018 dollars in millions)

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	●	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	○
• Demonstrate critical processes on a pilot production line	○	○
• Test a production-representative prototype in its intended environment	○	●

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

F-22 Inc 3.2B Mod Program

Technology Maturity and Design Stability

The program's sole identified critical technology, a geolocation algorithm, is mature as it has been flight-qualified in a realistic environment. At its October 2015 critical design review (CDR), the program had released all of its planned system-level drawings. The CDR was a culmination of multiple incremental CDRs, with the October 2015 review focused on software as the program had already completed its hardware reviews. Following CDR, however, the total number of drawings grew by over 70 percent in order to facilitate installation of the system across two different types of F-22 aircraft configurations. The new drawings also incorporate production efficiencies.

Production Readiness

The Principal Deputy Assistant Secretary of the Air Force (Acquisition and Logistics) approved Increment 3.2B for production in August 2016, 2 months later than planned but 1 month before the threshold date set at the start of program development. This production decision occurred after the program implemented a production readiness plan and completed qualification testing for the program's hardware components. The program office conducted an assessment of the production readiness in April 2016 and found that 95 percent of critical manufacturing processes met the DOD guidance for entering production. However, the contractor did not demonstrate manufacturing processes to be in statistical control prior to production start, which is inconsistent with best practices.

Increment 3.2B program officials have identified some production risks at an F-22 modernization program supplier. A Lockheed Martin supplier produces inertial navigation system units, a key component of the F-22 Raptor, that a separate program is incorporating into systems connected with Increment 3.2B. During incorporation these inertial navigation system units have failed to remain calibrated at an increased rate, and program officials are concerned that the contractor will not produce enough units on time to support installation of the third Increment 3.2B production lot. To mitigate this concern, the program is procuring a calibration service with the prime contractor.

Other Program Issues

According to program officials, a capability relating to navigation was not meeting its required performance in 2017. This capability is separate and distinct from the geolocation algorithm technology. In February 2017, the Air Force amended the associated performance requirement, and the capability currently meets the amended requirement. Program officials stated that this capability provides significantly improved performance over past systems.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.The program office told us that following the low-rate production decision, 134 of 203 design drawings were updated to permit their use for aircraft installation by including aircraft tail numbers to distinguish between two types of F-22 aircraft configurations: Block 30 and Block 35. The program noted that updating the initial design drawings to include tail numbers did not compromise the design stability of the program. The program office stated that as of August 2017, all 203 original design drawings had been released and 134 updated installation drawings are being released accordingly to support the May 2019 installation schedule.

In regard to demonstrating that manufacturing processes are in statistical control, program officials noted that the program has not completed inspections of the first units produced, and manufacturing readiness continues to mature as the program approaches its full rate production decision in July 2018.

Source: U.S. Air Force.

Family of Advanced Beyond Line-of-Sight Terminals Command Post Terminals (FAB-T CPT)

The Air Force's FAB-T program plans to provide a family of satellite communication terminals for airborne and ground-based users to replace many legacy communication terminals. In July 2015, DOD separated the FAB-T program into two subprograms: command post terminals (CPT), which we reviewed, and force element terminals (FET). CPT is expected to provide voice and data communications over military satellite networks for nuclear and conventional forces through ground command posts and E-6 and E-4 aircraft. FET is expected to provide capabilities on B-2, B-52, and RC-135 aircraft.

Program Essentials

Program office: Bedford, MA

Prime contractor: Raytheon

Contract type: Fixed-price incentive (firm target) (development)

Firm-fixed-price (low-rate initial production)

Next major milestone: Full-rate production (TBD)

Program Performance

(Charts not to scale)

(fiscal year 2018 dollars in millions)

Total quantities comprise 25 development quantities and 84 procurement quantities.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	…	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	…	○
• Complete a system-level preliminary design review	…	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	○	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	○
• Demonstrate critical processes on a pilot production line	●	●
• Test a production-representative prototype in its intended environment	○	●

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

FAB-T CPT Program

Technology Maturity and Design Stability

FAB-T CPT is comprised of five terminal configurations, some of which have different critical technologies. Two modification kit terminals adapt existing antennas for ground fixed and airborne platforms and are fully functional but will eventually be retrofitted with new antennas. The other three configurations use new antennas for ground fixed, ground transportable, and airborne platforms. According to the program office, the three configurations currently being produced—the two modification kit terminals and the new antenna ground fixed terminal—are now mature. Delays continue in developing the final two configurations—new antenna ground transportable and new antenna airborne terminals. The program previously planned for all of the new antenna terminals to be fully mature prior to the second lot procurement decision in July 2016, but according to officials, the ground transportable will be mature in March 2018 and the airborne will now likely not be ready for production until the end of 2018.

Production Readiness

In September 2015, FAB-T received verbal approval to begin production, followed by a formal acquisition decision in October 2015. At the time, FAB-T had not met best practices standard for beginning production, but, according to program officials, it met DOD's standards. The program has ordered a total of 42 terminals to date: 10 modification kit terminals in September 2015, 12 modification kit terminals in July 2016, and 5 modification kit terminals and 15 new antenna ground fixed terminals in June 2017. As of January 2018, the program has delivered 9 terminals, and has installed 4 to begin testing.

The program had expected to declare FAB-T initial operational capability by December 2019. However, in April 2017, the program reported a breach of its acquisition program baseline schedule for completion of operational testing, full-rate production, initial operational capability, and full operational capability. The program has yet to establish new dates for these milestones. The program attributed the delay in initial operational testing and full rate production to delays in developmental and production qualification testing and fielding. Further, the program attributed delays in initial and full operational capability to the limited availability of the E-4 and E-6 platforms for FAB-T installation.

In October 2015, the Under Secretary of Defense for Acquisition, Technology and Logistics authorized the FAB-T program to purchase more than 60 percent of its total units during low-rate production. Generally, programs must provide a rationale if low-rate production quantities will exceed 10 percent of total quantities, a situation where the program makes large funding commitments for systems that have yet to be proven operationally effective or suitable. FAB-T officials said that the higher number of units are required to demonstrate initial operational capability due to the various configurations and platforms needed. Officials said they plan to request permission to procure additional terminals before a full-rate procurement decision to take advantage of cost control opportunities from volume discounts. With the majority of terminals already approved, officials noted that initial operational testing would not significantly inform a full-rate decision.

Other Program Issues

Although FAB-T entered system development in 2002, the Air Force selected a new development contractor in 2012. Currently, only the CPT subprogram is in development and production. In July 2016, the Air Force submitted a strategy for achieving the FET requirements to the Secretary of Defense. In December 2017, the program completed a cost and capability analysis and is developing an acquisition strategy in preparation for a materiel development decision. Until the FET subprogram is executed, FAB-T cannot achieve its planned capabilities that are based on the interaction of bomber aircraft with intelligence, surveillance, and reconnaissance aircraft and CPTs.

FAB-T is designed to communicate through the Advanced Extremely High Frequency (AEHF) network of satellites, three of which have already been launched. Depending on how long delays continue, the first launched AEHF satellite might be nearing the end of its projected 14-year operational lifetime by the time FAB-T is available. All six AEHF satellites are expected to be on-orbit before FAB-T is operational. The lack of synchronization between the two programs has resulted in the underutilization of costly satellite capabilities.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. According to program officials, FAB-T has completed development of and is pursuing approval for the procurement of the ground transportable antenna configuration, and expects to complete airborne antenna development by the end of 2018. The program delivered a CPT for the first E-6 platform for integration during the preventative depot maintenance cycle which began in late 2017. Per program officials, they submitted a revised baseline in January 2018, with new key milestones that have been approved by the functional capabilities board and are on track for Joint Requirements Oversight Council approval. Program officials say they transmitted the FET cost capability analysis report to Air Force Global Strike Command in January 2018, and that preliminary funding in the fiscal year 2019 budget request would allow the program to develop a FET acquisition strategy in preparation for a materiel development decision.

Source: U.S. Air Force.

Global Positioning System III (GPS III)

The Air Force's Global Positioning System (GPS) III program plans to develop and field a new generation of satellites to supplement and eventually replace the GPS satellites currently in use. Other programs are developing the related ground system and user equipment. GPS III is intended to provide capabilities for a stronger military navigation signal, referred to as M-code, to improve jamming resistance and a new civilian signal that will be interoperable with foreign satellite navigation systems.

Program Essentials

Program office: El Segundo, CA

Prime contractor: Lockheed Martin

Contract types: Cost-plus-award-fee (development); Cost-plus-award-fee/Fixed-price incentive (production)

Next major milestone: Follow-on production contract award (early 2019)

Program Performance

(Charts not to scale)

(fiscal year 2018 dollars in millions)

We could not calculate GPS III cycle times because the initial capability depends on the availability of complementary systems. Total quantities comprise 2 development quantities and 8 procurement quantities.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	NA	NA
• Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	●	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	○
• Demonstrate critical processes on a pilot production line	○	●
• Test a production-representative prototype in its intended environment	○	○

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

GPS III Program

Technology Maturity and Design Stability

The GPS III program currently reports all eight of its critical technologies are mature and the design is stable. Lockheed Martin delivered the first GPS III satellite to the Air Force for storage in February 2017. However, the Air Force did not declare the satellite available for launch until September 2017 due to an Air Force investigation into the satellite's propulsion subsystem. The investigation, which affected multiple Air Force programs, was prompted by anomalies observed in the subsystem in other satellite programs. However, after testing multiple GPS III propulsion subsystems, the Air Force was satisfied with performance and therefore certified that the first GPS III satellite met all documented requirements.

Production Readiness

Projected deliveries of the GPS III satellites have become delayed beyond the program's January 2016 baseline schedule, due largely to problems with a subcontractor's ability to produce and deliver satellite navigation payload components, but also due to such factors as the propulsion subsystem. The Defense Contract Management Agency is projecting an average delay of 22 months for satellites 2 through 10. After missing the baseline schedule's February 2017 "available for launch" date for satellite 1, the Air Force declared that it would be unable to meet the baseline dates for the satellites 2 and 8. As result, in December 2017, the Air Force established a new baseline schedule for the program.

The Air Force states that it currently retains the option to purchase two additional GPS III satellites on the current production contract with Lockheed Martin. However, the Air Force plans to competively award a Fixed-Price Incentive (Firm Target)/Award Fee contract for production of no less than 22 GPS III follow-on satellites in early 2019, which the Air Force plans to procure as part of a separate acquisition program. The GPS III follow-on satellites will provide new performance enhancements, such as the capability to boost the strength of military M-code signals in contested and challenging environments. Ahead of that contract award, in May 2016, the Air Force reported that it awarded three production readiness feasiblitity contracts, each with a firm-fixed-price of $5 million, to Boeing, Lockheed Martin, and Northrop Grumman. The Air Force stated that these contracts would provide insight into the contractors' readiness for the production competition, as well as demonstrate navigation payload capability. Seven years after awarding the 2019 follow-on production contract, the Air Force plans to accept delivery of the first follow-on satellite.

Other Program Issues

The planned launch of the first GPS III satellite has shifted from March 2018 to late 2018, due to an Air Force decision in spring 2017 to launch the satellite on a SpaceX Falcon 9 rocket instead of a United Launch Alliance Delta IV rocket. The launch date change was necessary because a Falcon 9 rocket launch of the satellite would not be ready before May 2018, according to Air Force officials. Ongoing SpaceX efforts to validate and certify that the Falcon 9 is able to launch the GPS III satellite pushed the projected launch date beyond May 2018.

Because of extensive delays to OCX—the next generation GPS operational control system that will enable the full range of GPS III capabilities—the GPS III program expects to have delivered at least the first nine satellites and to have awarded a contract for additional satellites before operational testing of the satellite with OCX Block 1 confirms the satellite's modernized signal capabilities. This sequencing creates cost, schedule, and performance risk, since it limits Air Force corrective options if issues are discovered in testing.

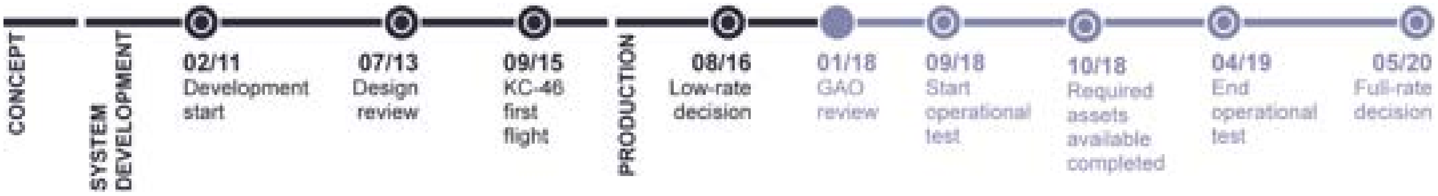
Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office also stated that the Air Force declared the first GPS III satellite available for launch in September 2017. The program office stated that this satellite is in storage ahead of a planned 2018 launch. It also said that the second GPS III satellite completed thermal vacuum testing—a key event that validates satellite performance in a simulated space environment—in December 2017. According to the program office, that second satellite is on track to deliver by August 2018. The program office further stated that the third through tenth GPS III satellites are currently in various stages of production.

Source: © 2016 Boeing Company - Photo by Paul Weatherman

KC-46 Tanker Modernization Program (KC-46A)

The Air Force's KC-46A program plans to convert an aircraft designed for commercial use into an aerial refueling tanker for operations with Air Force, Navy, Marine Corps, and allied aircraft. The program is the first of three planned phases to replace roughly a third of the Air Force's aging aerial refueling tanker fleet, comprised mostly of KC-135s. The Air Force has designed the KC-46A to improve on the KC-135's refueling capacity, efficiency, and capabilities for cargo and aeromedical evacuation, and to integrate defensive systems.



Program Essentials

Program office: Wright Patterson Air Force Base, OH

Prime contractor: Boeing

Contract types: Fixed-price-incentive (development)
Firm-fixed-price (production)

Next major milestone: Start of operational testing (September 2018)

Program Performance

(Charts not to scale)

(fiscal year 2018 dollars in millions)

Total quantities comprise 4 development quantities and 175 procurement quantities.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	…	NA
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	○
• Demonstrate critical processes on a pilot production line	●	●
• Test a production-representative prototype in its intended environment	●	●

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

KC-46A Program

Technology Maturity and Design Stability

The KC-46A's three critical technologies—two software modules related to situational awareness and a three-dimensional display that allows the crew to monitor aerial refueling activities—are fully mature. At its July 2013 critical design review (CDR), the program had released over 90 percent of its design drawings. At that time, the program stopped using design drawings to assess design status and instead began tracking approved development specifications and other design documents. Following CDR, Boeing discovered aircraft wiring deficiencies that have required it to re-design the wiring system to resolve separation issues. Boeing has since completed the required wiring modifications. Currently, the program relies on the Federal Aviation Administration's certification process to track design conformity and stability. However, because of the aforementioned deficiencies, and the fact that the program no longer tracks design drawings, we lack visibility into whether the design stability achieved at CDR has since been disrupted. As a result, we have updated our attainment of product knowledge table from what we reported in 2017 to reflect the unavailability of design drawing information.

During recent testing, Boeing discovered a critical issue that is resulting in design changes. It relates to the damage the KC-46A boom can cause to the aircraft it is refueling when it strikes the aircraft outside of the refueling receptacle. Of particular concern, these strikes can impact low observable aircraft coating, potentially making stealth receiver aircraft visible to radar. According to program officials, Boeing is developing a remote vision system software fix that would help avoid these unintended contacts with receiver aircraft. Boeing has not yet tested the fix. According to Boeing officials, as of January 2018, Boeing still needs to complete 24 percent of the planned KC-46A developmental test points. Until this testing is complete, Boeing may find additional technical issues that could require design changes.

Production Readiness

Boeing has manufactured four development aircraft and two low-rate initial production aircraft for use in testing. It is also in the process of producing 30 additional low-rate initial production aircraft. According to program officials, Boeing is completing some production work out of sequence due to the earlier wiring and other design issues. Boeing expects to resolve these inefficiencies by early 2018. Program officials state that they will continue to monitor and assess production readiness leading up to the full-rate production decision in May 2020. The program intends to purchase nearly 36 percent of its total aircraft during low-rate initial production. Generally, programs must provide a rationale if low-rate initial production quantities are going to exceed 10 percent of total quantities. The Under Secretary of Defense for Acquisition,Technology and Logistics approved this acquisition strategy for the KC-46A program to avoid a break in the production line.

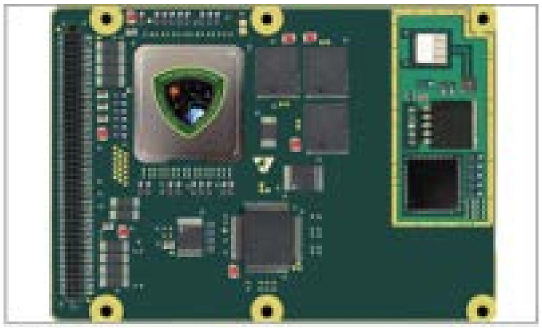
Other Program Issues

Boeing is continuing to have schedule challenges that affect when it can deliver the first 18 aircraft to the Air Force. Officials reported that in January 2017, Boeing and the program office modified the schedule to account for prior delays Boeing experienced in developing the KC-46A, including wiring challenges, a fuel component re-design, and a fuel contamination event. The Air Force and Boeing overcame these challenges, but lost time working through them. According to the program office, under the revised schedule, Boeing was supposed to deliver the first 18 aircraft with refueling booms and centerline drogue systems by February 2018, followed by the wing aerial refueling pod components in October 2018, 14 months later than the original date of August 2017. Boeing recently announced that it is experiencing some additional setbacks in meeting the revised schedule and now plans to deliver the first 18 aircraft by September 2018. Wing aerial refueling pod components are still expected to be delivered by October 2018. Program officials negotiated considerations from Boeing to account for lost military tanker capability associated with the delivery delays, such as obtaining additional training at no cost to the government for KC-46A pilots and maintenance personnel and support for the aircrew training system. Program officials expect a contract modification, including these considerations, to be finalized in early 2018.

There is risk of further delays as Boeing needs to ensure test aircraft have the latest wiring and software upgrades and that the wing aerial refueling pod's design is finalized and then tested. In addition, Boeing has not achieved its planned flight test pace and Boeing is revising test plans to account for additional time needed to complete receiver aircraft certifications required prior to KC-46 delivery.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.



Source: U.S. Air Force

Military Global Positioning System (GPS) User Equipment (MGUE) Increment 1

The Air Force's MGUE program plans to develop GPS receivers compatible with the military's next-generation GPS signal, "Military-Code." The modernized receiver cards will provide U.S. forces with enhanced position, navigation, and timing capabilities, and will improve resistance to threats, such as jamming efforts by adversaries. Increment 1, assessed here, leverages technologies from the Modernized User Equipment program to develop receiver test cards for aviation, maritime, and ground platforms. Increment 2 will develop smaller receiver cards and is planned to begin in 2018.

Program Essentials

Program office: El Segundo, CA

Prime contractors: L-3 Technologies, Raytheon, Rockwell Collins

Contract type: Cost-plus-incentive-fee/Firm-fixed-price (development; L-3 Technologies and Raytheon)

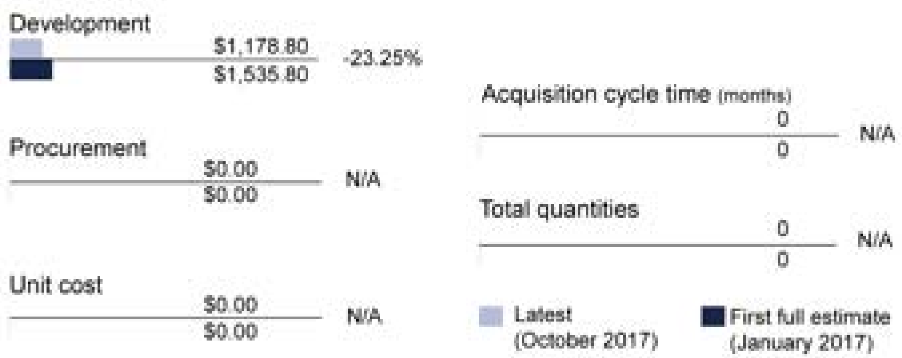
Cost-plus-fixed-fee/ Cost-plus-incentive-fee/Firm-fixed-price (development; Rockwell Collins)

Next major milestone: Start of operational testing (October 2019)

Program Performance

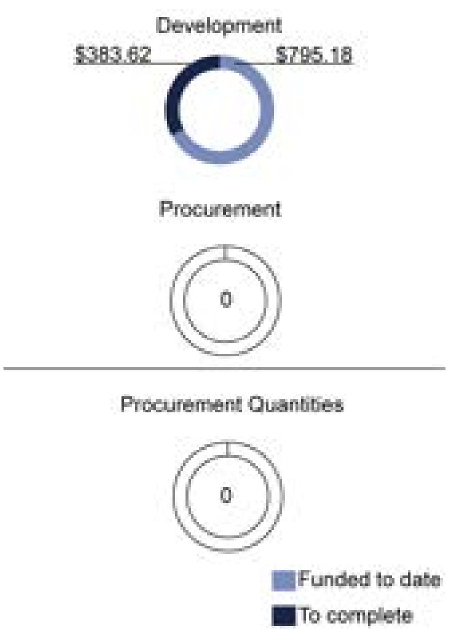
(Charts not to scale)

(fiscal year 2018, dollars in millions)



Remaining Funding Requirements

(fiscal year 2018 dollars in millions)



Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	NA	NA
• Test a system-level integrated prototype	NA	NA
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	NA	NA
• Demonstrate critical processes on a pilot production line	NA	NA
• Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

MGUE Increment 1 Program

Technology Maturity

The MGUE Increment 1 program entered system development in January 2017. The program office has assessed its military-code acquisition engine, military-code cryptography, and selective availability anti-spoofing module functionality technologies as fully mature. The remaining two critical technologies—anti-spoof and anti-tamper—are still nearing maturity. While the program previously considered anti-tamper as mature, only one of three contractors had achieved maturity, and re-assessed that the technology will be fully mature when all contractors achieve anti-tamper certification. The technology maturity levels were based on a 2014 technology readiness assessment that DOD's Director, Operational Test and Evaluation concluded was an overstatement of maturity, since, among other things, the tests did not include final hardware or software configurations. Since that time, the program has conducted additional product demonstrations as part of hardware and software developmental tests, although the receiver cards still do not have full software configuration. The contractors have delivered incremental anti-spoof capability, and the program anticipates evaluating anti-spoof and anti-tamper techniques in fiscal year 2018.

Design Stability

We previously recommended that the program incorporate a key design assessment, the critical design review (CDR), to show whether the MGUE design was stable prior to lead platform testing. However, DOD formally eliminated this review from the acquisition program in January 2017. According to program officials, the design is stable, and any design problems will now be found in testing.

In 2017, contractors delivered final hardware test cards for laboratory tests. The Air Force has granted security certification to the "common core" component of one contractor's receiver card—a key step for platforms and services to procure and integrate receiver cards. According to program documents, security certification for the other two contractors' receiver cards is still months away. The program office reports that none of the receiver cards delivered include all of the required software and, in some cases, will need to be returned to the contractors for final configuration. In addition, some military services have already identified gaps between what MGUE will provide and what the services will need, such as certain heat and power capabilities. The Air Force must also address new requirements for the receiver cards to be compatible and communicate with existing weapon systems.

Production Readiness

MGUE will not have a scheduled production decision, and the program's acquisition strategy does not provide for procurement beyond final test articles. Instead, the program will end with, among other criteria, operational testing of the first available test cards on four, service-specific lead weapon systems. Program offices for these four and other weapon systems will then determine whether to undertake additional development and tests to integrate the receiver cards, identify their required quantities, and contract for production of those quantities. This level of development and procurement effort will be significant among DOD programs. While some common solutions are being developed, individual organizations have the flexibility to pursue their own uncoordinated receiver card programs at different times and with different contractors.

Other Program Issues

The full cost and schedule for implementing military-code receiver cards across DOD remains unknown. As of February 2017, DOD had determined that 716 weapon systems will need military-code receiver cards; however, it only identified $2.5 billion in partial costs associated with 28—less than 4 percent—of those weapon systems. The estimate was based on military code implementation plans submitted by the military services, Missile Defense Agency, and Special Operations Command. Due to immaturity of the receiver card technology, the implementation plans were used to support waiver requests from the National Defense Authorization Act for Fiscal Year 2011 requirement that generally prohibits DOD from obligating or expending funds to purchase GPS user equipment after Fiscal Year 2017 unless that equipment is capable of receiving military-code signals.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. It stated that MGUE continues to conduct risk reduction testing on vendor hardware and incremental software to ensure designs are stable and well-understood. The program also said the Air Force conducted successful early developmental testing in 2017 on the B-2 platform with a prototype MGUE card. Additionally, it said the Army conducted field tests to assess the maturity of MGUE Increment 1 technology for precision-guided munitions. According to the program office, it has been proactive in addressing new requirements for MGUE to ensure receiver cards are compatible and communicate with existing weapon systems. The program said that a capability related to legacy weapons has been added to MGUE baseline requirements. It noted that the requirements community subsequently clarified requirements for a new GPS message type that will require changes, which the program is evaluating, to the MGUE Increment 1 program and other GPS segments. Program officials also referenced cost and quantity updates they generated for the fiscal year 2019 President's Budget.

Source: U.S. Air Force

Next Generation Operational Control System (OCX)

The Air Force's OCX program is primarily a software development effort to replace the existing Global Positioning System (GPS) ground control system. Intended to ensure reliable, secure delivery of position and timing information to military and civilian users, OCX software will be delivered in blocks that each provide upgrades as they become available. We assessed the first three blocks: Block 0 for launch and initial, limited tests of new satellites; Block 1 for satellite control and basic military signals; and Block 2 for modernized military and additional navigation signals.

Program Essentials

Program office: El Segundo, CA

Prime contractor: Raytheon

Contract type: Cost-plus-incentive-fee (development)

Next major milestone: Re-entry into system development (April to June 2018)

Program Performance

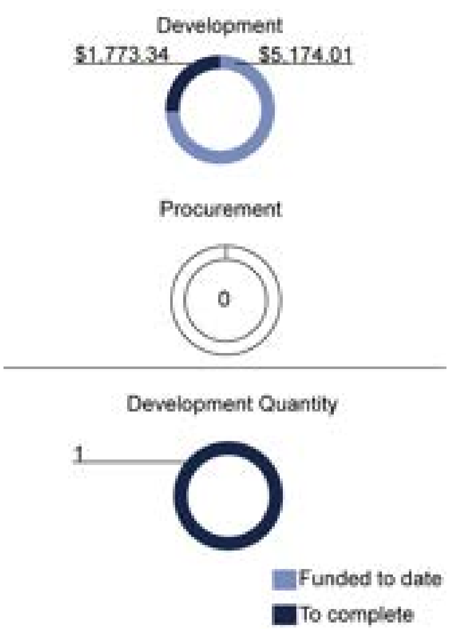
(Charts not to scale)

(fiscal year 2018 dollars in millions)

Latest program costs reflect the October 2015 acquisition program baseline, which DOD rescinded in October 2016. The Air Force developed a new, unapproved baseline and is using development funds to acquire the system.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)



Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	NA	NA
• Test a system-level integrated prototype	NA	NA
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	NA	NA
• Demonstrate critical processes on a pilot production line	NA	NA
• Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

OCX Program

Technology Maturity and Design Stability

The OCX program previously assessed 14 critical technologies as mature. For this assessment period, the program reported only five critical technologies that are nearing maturity. The program does not track the metrics we used for this assessment to measure design stability, such as the number of releasable design drawings, as OCX is primarily a software development effort.

OCX entered system development in November 2012. From early on, the program struggled with significant cost and schedule growth that, in 2013, led the Air Force to pause the program's development. The Air Force found that OCX cost and schedule growth stemmed from numerous root causes, including a poor understanding between the contractor and the Air Force on the program's key performance requirements. The contractor found that this lack of understanding was particularly significant for the system's cybersecurity requirements, which led to software development difficulties.

In October 2015—after an independent assessment of the program, cost and schedule were updated, and departmental reviews were held—the Air Force re-baselined the program's cost and schedule estimates and restarted OCX software development activities. Nonetheless, this restart occurred before the program had fully addressed the root causes that led to the 2013 pause, which then caused new disruptions. In December 2015, 2 months after the Air Force's re-baseline, the Under Secretary of Defense for Acquisition, Technology and Logistics directed a 24-month schedule extension to Block 1 that postponed the OCX software delivery to December 2020, a timeframe that was recognized as aggressive.

In June 2016, following additional cost growth and departmental reviews, the Secretary of the Air Force notified Congress of a critical statutory unit cost breach in the program. DOD also conducted a second root cause analysis as a requirement to recertify the program and resume development. This analysis found that (1) external factors drove the program to an unrealistic schedule, (2) costs to fully implement information assurance requirements were underestimated, and (3) both the contractor and government had performed poorly. In October 2016, the Air Force subsequently restructured the program to (1) repeat the program review associated with entry into system development, which the program office held in June 2017, (2) re-estimate the program's cost, and (3) add 6 more months to Block 1 efforts and deliver Blocks 1 and 2 concurrently in June 2021. In September 2017, the contractor delivered OCX Block 0, a subset of software from Block 1 that provided the capabilities needed to launch and test GPS III satellites. The Air Force took possession in October 2017 and will finally accept it when Block 1 is delivered.

As of January 2018, DOD has not completed an independent cost estimate for OCX, which has precluded approval of the new program schedule and cost proposed in June 2017.

Other Program Issues

The current program schedule assumes (1) higher levels of software coding productivity than the program has historically demonstrated and (2) an assumed ability to discover and fix software defects earlier in the development process under a new software development methodology, which the program has yet to fully implement. The program does not anticipate proving some of its anticipated productivity gains and earlier discovery and corrections of defects until the end of fiscal year 2018. Further, the program nearly doubled its contractor staff in the year following December 2015 to meet the directed 24-month program extension. Contractor staff that support the program now total nearly 1,000 people each month. The contractor's prior forecasts indicated that staff totals would decline by the middle of 2017, but those reductions have yet to be realized. According to the Air Force program manager, the staff levels are consistent with Air Force cost projections. However, the increased staff count is driving continued cost growth on the program since most of the expenses for the program pay for personnel to code and correct software.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.The program office stated that the Air Force accepted Block 0 on October 26, 2017, after verifying that Raytheon satisfied 100 percent of the 3,306 contract requirements. According to the program, Raytheon continues to actively support the path to launch of the first GPS III satellite scheduled for 2018. Additionally, the program office said that the Air Force restructured the remaining Block 1 and 2 contract schedule as part of the rebaseline activities after recertification. It stated that the new contract reflects a June 2021 acceptance date from the contractor, and the Air Force has assessed 7 months of risk to meeting that date. According to the program office, it has undertaken a comprehensive review of the program's schedule and cost, which it plans to complete in April 2018. Program officials stated that this comprehensive review will inform completion of an independent cost estimate, which will in turn support completion of the system development review and approval of an acquisition program baseline.

Source: © 2009 Raytheon Company

Small Diameter Bomb Increment II (SDB II)

The Air Force's Small Diameter Bomb Increment II (SDB II) is a joint interest program with the Navy and is designed to provide attack capability against mobile targets in adverse weather from extended range. It combines radar, infrared, and semi active laser sensors in a tri-mode seeker to acquire, track, and engage targets. It uses airborne and ground data links to update target locations, as well as a global positioning system and an inertial navigation system to ensure accuracy. SDB II will be integrated with Air Force and Navy aircraft, the F-15E, F/A-18E/F, and F-35 aircraft, among others.

Program Essentials

Program office: Eglin Air Force Base, FL

Prime contractor: Raytheon

Contract types: Fixed-price incentive (development)
Fixed-price incentive (low-rate initial production)

Next major milestone: Start of operational testing (April to June 2018)

Program Performance

(Charts not to scale)

(fiscal year 2018 dollars in millions)

Total quantities comprise 163 development quantities and 17,000 procurement quantities.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	…	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	○
• Demonstrate critical processes on a pilot production line	●	●
• Test a production-representative prototype in its intended environment	●	●

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

SDB II Program

Technology Maturity and Design Stability

SDB II's four critical technologies—guidance and control, multi-mode seeker, net ready data link, and payload—are mature. These technologies were not mature until May 2015, almost 5 years after development start. The program reported that SDB II had a stable design at its January 2011 design review. After production start, qualification and flight test failures revealed deficiencies in SDB II's design that required hardware and software changes. Even so, the program reported it has currently released 100 percent of design drawings. Due to the aforementioned changes, and because, according to officials, the contractor does not track revisions to previously released design drawings, there is not visibility into whether the design stability reported at critical design review has since been disrupted. We have updated our attainment of product knowledge table from what we reported in 2017 to reflect this lack of visibility.

Since October 2016, the program has conducted a Government Confidence Test (GCT) phase, which is intended to conduct 28 shots in flight in normal attack mode. The program added these tests at the direction of the Office of the Secretary of Defense to test against additional, real world scenarios. To date, the program conducted tests of 24 shots. Four tests did not achieve their objectives. Specifically, one did not impact a moving target, two did not impact a stationary target, and one did not impact a stationary wheeled target at long range. A fifth test missed its target but detonated near the target, and officials stated it was deemed successful. They said these failures were largely the result of software deficiencies and most involved problems with the aircraft relaying inaccurate or incomplete information to the weapon. These failures and issues scheduling the test range resulted in a 5-month flight test delay. The program has released new software updates to address these failures and has plans for further updates.

Continued software rework and flight-test failure investigations have further delayed GCT flight tests to the extent that the program is now at risk of a schedule breach. Following completion of the GCT, the program plans to conduct 55 operational test shots over a 1-year period. To help mitigate a possible schedule breach, program officials stated they may count some development flight tests towards the 55 total shot operational tests to reduce the overall number of tests needed.

Production Readiness

In prior assessments, we have reported that SDB II manufacturing processes were mature. However, based on updated information provided by the program office for our 2018 assessment, we determined that the program has not achieved this maturity.

The program reports that the contractor began low-rate initial production of the first 144 units (Lot 1) in March 2017 with a 2-month delayed delivery date for some necessary rework, from the end of August 2017 to the end of October 2017. Officials reported it awarded a second production contract (Lot 2) in September 2016 for 250 additional units, a third contract (Lot 3) in January 2017 for 312 additional units, and a fourth contract (Lot 4) in February 2018 for 570 units. Officials reported that, as of February 2018, 65 Lot 2 weapons were delivered according to the contract schedule.

The Air Force is the sole customer for the first three production lots. The program office stated that the Navy does not intend to procure any SDB II quantities until Lot 4, and that the Navy may be affected by funding limitations under continuing resolutions. In fiscal year 2013, the Navy revised its platform integration strategy because it plans to field SDB II from F/A-18E/F aircraft prior to integrating it with F-35 aircraft. Officials said that the weapon’s integration with the F/A-18E/F is scheduled for fiscal year 2020 and integration with the F-35 for September 2022.

Other Program Issues

In 2017, the contractor reported cost growth on contracts covering the first three production lots. Program officials said they expect this growth to occur in the first five production lots and stated it is due to the contractor’s overly aggressive cost proposals early in the system development phase as well as necessary rework affecting initial production lots. Officials stated that the government’s liability for cost growth is capped by the production contracts’ terms and that the contractor is exploring opportunities to reduce production costs. Officials added that the use of a fixed-price incentive contract reduces the cost risk for the government because the contractor generally must absorb costs that exceed the price ceiling.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program stated that developmental testing is nearing completion; entry into initial operational testing is planned for the third quarter of fiscal year 2018; and simulated target testing, known as captive carry testing, is scheduled through fielding of the first five production lots. It also said that the contractor has manufactured over 370 weapons during low-rate initial production, and the program expects to demonstrate manufacturing process controls during production of Lot 4. The program also said it reached agreement with Australia to provide SDB II testing and training assets and support.

Source: U.S. Air Force

Space Fence Ground-Based Radar System Increment 1 (Space Fence Inc 1)

The Air Force's Space Fence Inc 1 program is developing a large, ground-based radar to detect and track objects in low and medium Earth orbit and provide this information to a space surveillance network. Space Fence is designed to use high radio frequencies to detect and track more and smaller objects than previous systems. The Air Force awarded a development and production contract for the first radar site in June 2014. This contract included an option that, if exercised, would enable the Air Force to acquire a second site under a separate program.

Program Essentials

Program office: Hanscom Air Force Base, MA

Prime contractor: Lockheed Martin

Contract type: Fixed-price incentive (development and production)

Next major milestone: Start operational testing (January 2019)

Program Performance

(Charts not to scale)

(fiscal year 2018, dollars in millions)

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	●	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	NA	NA
• Demonstrate critical processes on a pilot production line	NA	NA
• Test a production-representative prototype in its intended environment	NA	NA

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

Space Fence Inc 1

Technology Maturity and Design Stability

In February 2015, the Air Force completed a technology readiness assessment that showed that all seven of the program's critical technologies are fully mature. The program achieved technology maturity by integrating the technologies into a prototype radar array and demonstrating that array in an operational environment. Space Fence's critical technologies provide capabilities for transmitting and receiving radar signals from the radar array.

In early 2016, the program office began testing a new prototype that uses production-representative hardware and runs the same software designed for the operational radar. According to program officials, this prototype has helped informally test about 90 percent of the systems that will be installed on the operational radar and it has demonstrated that the Space Fence design is, to date, capable of meeting 70 percent of the program's performance requirements.

Production Readiness

According to program officials, production of the radar components is about 99 percent complete. The remaining 1 percent of production is for a component in one of the radar's power supply cabinets.

The program continues to face delays with construction of both the facility that will house the radar and of the power plant for the radar. These delays, which the program attributes to difficult site conditions and poor contractor and subcontractor performance, now total 4 months. The delays led the program office to postpone initial operational capability from January 2019 to May 2019. This postponement means the program office has significantly reduced its available schedule margin, and any further delays could jeopardize the program's ability to meet its scheduled operational date.

Other Program Issues

The Air Force expects Space Fence Inc 1 to meet its requirements for initial operational capability; however, it only plans to declare full capability if and when a second site becomes operational. The Air Force has included development and production of a second site, which would comprise an Increment 2 program, as a contract option. Program officials stated that the Air Force has yet to formally decide whether to fund Increment 2. Regardless, program officials stated that no contract actions related to Increment 2 would occur until after Increment 1 achieves initial operational capability in May 2019. By then, according to program officials, the contract pricing terms for the option will likely have expired and the program may need to renegotiate the price for Increment 2 with the contractor.

In addition, the Joint Space Operations Center (JSpOC) at Vandenberg AFB is acquiring new data processing capabilities under its JSpOC Mission System (JMS), designed in part to enable processing of the increased volume of data expected from Space Fence. However, the JMS program office has experienced schedule delays previously and again over the past year. The Air Force has delayed planned completion of developmental testing of JMS software from February 2018 to August 2018. According to the Space Fence program office, this software is needed for Space Fence developmental testing in October 2018. Although the JMS schedule currently supports Space Fence testing plans, Space Fence program officials stated that additional JMS software delays could require them to complete developmental testing using an alternative software program to simulate JMS capabilities, rather than the actual software. Any future JMS delays could also prompt the Space Fence program to use this approach to complete Space Fence operational testing. However, this approach would require accreditation of the model—an activity for which the Air Force has not budgeted or planned.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. Space Fence program officials also stated that the program continues to move closer to delivering an improved Space Situational Awareness capability. The program noted that sensor site construction is near completion, and that a planned power plant annex will soon come online, critically augmenting the existing power plant at U.S. Army Garrison Kwajalein Atoll. Program officials stated that full installation and checkout of radar array elements continues, and a portion of the radar array will be in place for a first track by the sensor site in mid-2018. Program officials also stated that they continue to conduct regular assessments of Space Fence integration with the Joint Space Operations Center Mission System to fully test the interface, building towards end-to-end tests in the second half of 2018. According to the program office, Air Force officials are also in discussions with Australian officials to support a survey of the proposed Increment 2 site, although the Air Force has not yet formally committed to an Increment 2 program.

Source: U.S. Air Force.

Advanced Pilot Training (APT)

With its APT program, the Air Force is replacing its legacy T-38C trainer fleet and related ground equipment by developing and fielding newer, more technologically advanced trainer aircraft and an associated ground-based training system. The APT program responds to the Air Force's advanced fighter pilot training needs and seeks to close training gaps that the T-38C cannot fully address.

Program Essentials

Program office: Wright-Patterson Air Force Base, OH

Prime contractor: TBD

Contract type (planned): Indefinite-delivery indefinite-quantity with delivery orders:

- Fixed-price incentive (development)
- Fixed-price incentive and firm-fixed-price (production)

Next major milestone: Development start (by summer 2018)

Estimated Program Cost

(Cost figure reflects fiscal years 2016-2022; fiscal year 2018 dollars in millions)

Planned Quantities

Current Status

In October 2009, the Air Force identified 12 gaps in its aircraft training capabilities. In May 2010, the Under Secretary of Defense for Acquisition, Technology and Logistics approved the Air Force's plans to conduct an analysis of alternatives for closing that gap. In June 2011, the analysis of alternatives recommended that the existing training aircraft, the T-38C, be replaced because a modification program would not be cost effective, nor would it address all the identified capability gaps.

In response, the APT program plans to compete and award an indefinite delivery/indefinite quantity contract to a single source for system development, production of an estimated 351 trainer aircraft ground-based training systems and initial sustainment. The Air Force solicited proposals for this source selection in December 2016 ahead of a planned contract award of December 2017. In October 2017, the Air Force delayed the contract award to allow time for the source selection team to ensure that proposals were properly evaluated. Air Force officials now plan to award the contract by summer 2018 and stated that they do not expect the revised contract award date to affect the schedule for future milestone events in the program.

The APT program's acquisition approach is based on the employment of mature technology for timely fielding of the APT system. According to Air Force officials, all prospective vendors will offer systems that are well beyond the prototype phase and will include flight-test data from aircraft that closely match the offered aircraft. As a result, the program does not plan to conduct a preliminary design review until after development start, for which the program office will request a statutory waiver.

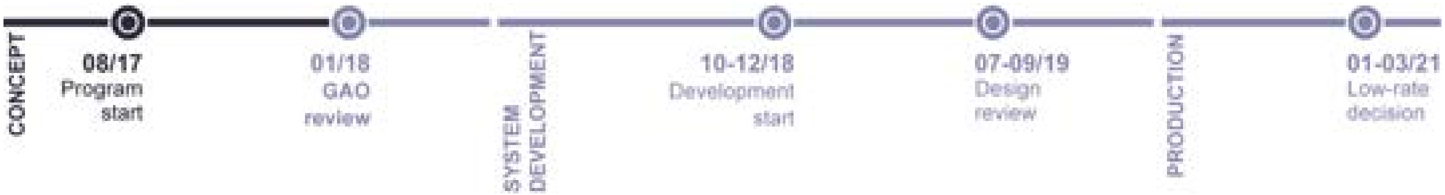
Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

Source: U.S. Air Force.

B-2 Extremely High Frequency Satellite Communications (B-2 EHF SATCOM)

The Air Force's B-2 EHF SATCOM is one of several efforts to modernize and upgrade the B-2 bomber aircraft. B-2 EHF SATCOM will replace an aging system with a new one to provide reliable, two-way, secure, and survivable communications capability to the B-2 during conventional and nuclear missions. This effort includes technology maturation leading to the development, procurement, and installation of radio, antenna, and related components.



Program Essentials

Program office: Wright-Patterson Air Force Base, OH

Prime contractor: TBD

Contract type: TBD

Next major milestone: Development start (October to December 2018)

Estimated Program Cost

(fiscal year 2018 dollars in millions)

Planned quantities

Current Status

In 2017, the Air Force placed the B-2 EHF SATCOM program on hold—a status that remained in place at the time of our review. According to program officials, this hold resulted from analysis that projected the program would deliver a poor return on investment. Consequently, the program reported that it is not planning to request funding for fiscal year 2019. Funding budgeted for the effort in fiscal years 2016 through 2018 totaled $170.44 million.

The Air Force initially planned to develop the B-2 EHF SATCOM system in three increments. The program began Increment 1 development in 2007 and completed it in 2016 at a cost of $540.4 million. This increment upgraded the B-2's computing and information systems so the EHF SATCOM system could be installed and to allow for other future upgrades. In December 2013, the Air Force terminated the other two increments—which, together, would have enabled the B-2 to interface with DOD's information technology infrastructure—because of funding uncertainties and delays in a related program that would have provided B-2 communications terminals.

In October 2016, the Air Force initiated plans to combine the previously canceled increments under a new B-2 EHF SATCOM program. At that time, the Air Force estimated that this new program would cost $1.18 billion in total and planned to begin technology development in the fourth quarter of fiscal year 2017.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program stated that the Air Force intended to provide a system that ensured secure command and control communications in modern battlespace. It also said the system was intended to replace an existing satellite communication system. According to the program, the Air Force's "Bomber Vector" roadmap established future planning guidance for the bomber force. Per program officials, the Air Force developed a plan to retire the B-2A bomber as the B-21 bomber begins fielding, while still maintaining the necessary force structure for both nuclear and conventional missions. Officials further said that, based on the timing of that transition, it was not prudent to continue EHF SATCOM as B-2 retirements would begin less than a decade after the EHF SATCOM systems were fielded.

Source: U.S. Air Force

Ground Based Strategic Deterrent (GBSD)

The Air Force's GBSD is replacing the aging Minuteman III, the land-based component of the nuclear triad providing strategic deterrence. GBSD will include new missile systems, weapon system command and control, and ground systems, as well as restored and modernized Minuteman III silos. GBSD aims to improve performance and affordability over the Minuteman III and be more adaptable to changing technologies and new threat environments as they arise from the first fully integrated weapon system, projected in fiscal year 2029, through 2075.

Program Essentials

Program office: Hill Air Force Base, UT

Prime contractors: Northrop Grumman and Boeing

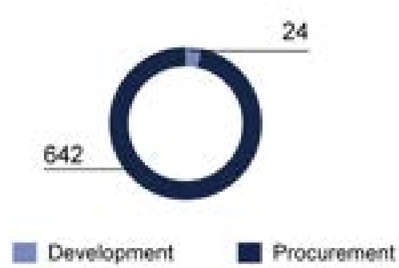
Contract type: Cost-plus-fixed-fee (technology maturation and risk reduction)

Next major milestone: Development start (September 2020)

Estimated Program Cost

(fiscal year 2018 dollars in millions)

Planned missile quantities



Current Status

The Air Force started technology development on the GBSD in August 2016. The program office later awarded two technology maturation and risk reduction contracts, both for a period of 36 months, in August 2017. To ensure that GBSD is delivered by 2029, the Air Force's acquisition strategy relies on using low risk, mature technologies. As such, the program's focus during the technology development phase is on risk reduction with minimal focus on technology maturation. Contractors plan to demonstrate a set of subsystem prototypes and deliver a preliminary design for a complete, integrated weapon system to the government by mid-2020. The program office's plan to conduct preliminary design reviews prior to entering system development in fiscal year 2021 aligns with acquisition best practices and statutory requirements.

Uncertainties in GBSD acquisition costs led officials in the Office of Cost Assessment and Program Evaluation (CAPE) to present DOD decision makers at Milestone A with two independent cost estimates between 34 percent and 139 percent higher than the Air Force's initial estimate for its acquisition budget. Government officials cited estimating challenges such as:

- gaps in historical cost data from analogous systems dating back to the 1960s or 1980s,
- differences in labor rates used to project costs up to 60 years in the future,
- lack of definition in key aspects of the weapon systems, particularly the ground systems, and
- differences in both the timing of costs and projected duration of development.

DOD ultimately selected the CAPE lower estimate as its official initial cost position. In 2018, the program office expects to obtain updated estimates—further informed by contractors' design choices—although many of the same data limitations will still apply.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

Source: U.S. Air Force.

Joint Surveillance Target Attack Radar System Recapitalization (JSTARS Recap)

With its JSTARS Recap program, the Air Force seeks to replace aging JSTARS aircraft—manned Battle Management Command and Control (BMC2) systems that provide surveillance and information on moving and stationary ground targets—at reduced operating and sustainment costs, replace and improve JSTARS capability, and minimize development and integration costs. The Air Force plans to integrate new aircraft, radar, communications, and BMC2 subsystems as part of the JSTARS Recap program.

Program Essentials

Program office: Hanscom Air Force Base, MA

Prime contractors: TBD

Contract type: TBD

Next major milestone: Development start (August 2018)

Estimated Program Cost

(fiscal year 2018 dollars in millions)

Planned quantities

Current Status

The fiscal year 2019 President's Budget request did not include a request for fiscal year 2019 funds for the JSTARS recap program. The Air Force has been in the process of re-evaluating its planned investment in the program to assess whether they should use other systems, such as a disaggregated network of sensors and satellites, to meet its mission. The outcome of this review will inform whether the Air Force should proceed with JSTARS Recap or not.

Previously, the JSTARS Recap program had undertaken key systems engineering efforts ahead of its planned August 2018 development start. The program reported that in March 2016, it awarded separate radar risk reduction contracts to Northrop Grumman and Raytheon to advance planned radar subsystem maturity and reduce schedule risks. According to program officials, for the 2018 planned development start, the Air Force reviewed and established a competitive range of the most highly rated contractor proposals that offered the Northrop Grumman radar system, including Boeing, Lockheed Martin, and Northrop Grumman. The program also completed a technology readiness assessment in June 2017 that identified three critical technologies—radar assembly, UHF/VHF filter, and VHF/UHF line of sight radio (transceiver)—that ranged from immature to nearing maturity. According to program officials, they have no plans to continue to mature technology during system development. Instead, program officials stated that each of the current contractors has other mature, commercially available components to use in place of any immature technologies, if necessary.

Program Office Comments

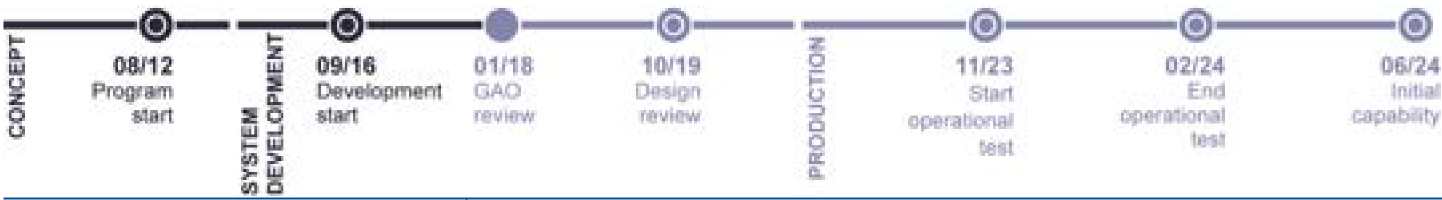
We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

According to the program office, it expects to continue with source selection even though the President's Budget request for fiscal year 2019 does not fund the program. The program stated that this will allow senior leaders time to respond to potential direction from Congress, such as direction to continue. According to the program office, under such a scenario, it would then award a contract and begin development.

Source: Boeing Corporation.

VC-25B Presidential Aircraft Recapitalization (PAR)

The Air Force's PAR program plans to replace the current VC-25A presidential aircraft with a new modified commercial plane to transport the President of the United States. The PAR aircraft will be a four engine widebody, commercial derivative aircraft, uniquely modified to provide the President, staff, and guests with safe and reliable air transportation with the same level of security and communications capability available in the White House.



Program Essentials

Program office: Wright-Patterson Air Force Base, OH

Prime contractor: Boeing

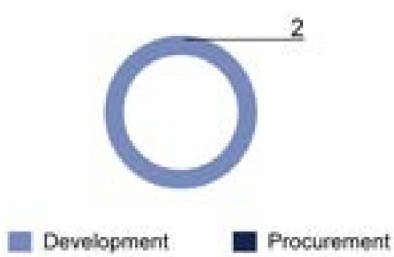
Contract types: Firm-fixed-price (commercial aircraft)
Cost-plus-award-fee (preliminary design)

Next major milestone: Modify base contract to start system development (August 2018)

Estimated Program Cost

(fiscal year 2018 dollars in millions)

Planned Quantities



Note: PAR program is not yet baselined; estimated costs reflect information in the fiscal year 2018 budget.

Current Status

In September 2016, the Under Secretary of Defense for Acquisition, Technology and Logistics (USD AT&L) approved the PAR program for entry into system development. Following this approval, the Air Force solicited proposals for system development and, in August 2017, purchased two Boeing 747-8 aircraft under firm-fixed-price terms.

USD AT&L waived several requirements for the program to assess affordability, assess technology maturity, and complete a preliminary design review that are supposed to occur prior to entering system development. USD AT&L determined that without such waivers, the acquisition of the new aircraft and replacement of the legacy aircraft would be significantly delayed, and DOD would be unable to meet critical national security objectives. Since then, the program has operated without an approved acquisition program baseline, which currently precludes us from analyzing cost and schedule performance in a two-page assessment format.

The Air Force plans to modify its contract with Boeing in August 2018 to start PAR development activities in earnest. In the interim, Boeing is completing preliminary design activities for PAR, and the program continues risk reduction activities first initiated in 2012. Further, a task force of Air Force and Boeing officials are assessing affordability and schedule concerns prior to the program establishing an acquisition program baseline and awarding the planned contract modification.

The program plans to modify and test both aircraft in a phased approach starting in 2019, using research and development funding. By fiscal year 2024, the Air Force plans to accept delivery of aircraft that are fully capable to support presidential missions.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate.

Source: U.S. Air Force

Utility Helicopter (UH-1N) Replacement

The UH-1N Replacement program aims to replace the Air Force's 63-helicopter fleet, initially manufactured in the 1960s. The UH-1N helicopter's primary missions are securing intercontinental ballistic missile sites and convoys, and transporting senior government officials in the National Capital Region. However, the program office reports that the current fleet does not comply with DOD's nuclear weapons security guidance and cannot meet all mission requirements. The program plans to acquire 84 helicopters, an integration laboratory, a training system, support and test equipment, and associated software.

Program Essentials

Program office: Wright-Patterson Air Force Base, OH

Prime contractor: TBD

Contract type (planned): Firm-fixed-price

Next major milestone: Contract award (June 2018)

Estimated Program Cost

(fiscal year 2018 dollars in millions)

Planned quantities

Current Status

The Air Force established the UH-1N Replacement program in fiscal year 2016. The program's acquisition strategy anticipated a competitive, full and open, best value tradeoff source selection and the program reports it plans to award a contract in June 2018.

The Air Force completed an analysis of alternatives in June 2015 and issued an initial request for information to industry as part of its market research in August 2015. At that time, the Air Force planned to start the program with an initial production decision. However, based on the responses to the request for information, the Air Force determined that the contractors' existing helicopters could not meet program requirements without modifications. Therefore, the Air Force altered its approach and, in April 2017, chose to start the program earlier in the acquisition life cycle. According to program documents, this revised approach will help contractors meet all program requirements by giving them an opportunity to add existing components to their existing airworthiness-certified helicopters.The program now plans to make an initial production decision at the end of fiscal year 2020.

The program office identified cybersecurity and workforce risks. The program office has decided to accept cybersecurity risks when it chose to use an existing helicopter. Officials stated that the program may procure a helicopter that does not meet current cybersecurity standards. In addition, the program office told us of significant workforce risks. Specifically, it has had difficulties in hiring government personnel with the required engineering, avionics, and defense systems expertise.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. According to the program office, its strategy to acquire an existing helicopter limits its ability to insert additional cybersecurity requirements. Consequently, the program office stated that it will assess and actively manage cyber risks. The program office also said that it is working to hire additional qualified personnel.

Source: U.S. Air Force.

Weather System Follow-On—Microwave (WSF-M)

The Air Force's WSF-M is intended to contribute to a family of space-based environmental monitoring (SBEM) systems by providing 3 of 11 mission critical capabilities in support of military operations. WSF-M is being developed to conduct remote sensing of weather conditions, such as wind speed and direction at the ocean's surface, and provide real-time data to be used in weapon system planning and weather forecasting models. The family of SBEM systems replaces the Defense Meteorological Satellite Program.

Program Essentials

Program office: El Segundo, CA

Prime contractor: Ball Aerospace and Technologies Corporation

Contract types: Firm-fixed-price (system design)
Firm-fixed-price (development and fabrication)
Cost-plus-incentive-fee (integration, test, and operations)

Next major milestone: Preliminary design review (December 2018)

Estimated Program Cost

(FY 2018 dollars in millions)

Planned Quantities

Current Status

WSF-M is planned as a polar-orbiting satellite with two payloads: a microwave imager to collect data on ocean surface vector wind and tropical cyclone intensity; and an energetic charged particle sensor to collect space weather data. In November 2017, the Air Force awarded a contract for system design with options for system development and fabrication as well as integration, test, and operations. The Air Force plans to start system development in March 2019 and launch a satellite by December 2022. The acquisition strategy includes one satellite and an option for a second, if needed based on operational risk, which would function in the same way as the first. WSF-M is to be integrated into the Enterprise Ground Services, a common ground system for satellites.

As a precursor to WSF-M, the Air Force has undertaken a technology demonstration program using an existing microwave sensor and plans to launch it in June 2018. According to program documentation, this demonstration will partially meet SBEM requirements and will inform WSF-M technology development. The acquisition strategy states that the earliest possible launch of the technology demonstration and WSF-M are critical to mitigate potential capability gaps. A gap in full coverage between 2018 and the WSF-M launch in 2022 is possible, however, as WindSat, the only satellite that fully meets the service's needs for ocean surface vector wind data, is operating well beyond its intended mission life.

Air Force plans call for WSF-M to enter development with one critical technology—the polarimetric receiver—which is currently at a TRL 5. The program office no longer considers the bearing and power transfer assembly to be a critical technology because it will likely be the same form, fit, and function as that used on a payload currently in orbit.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. In its comments, the program office noted a full and open competition was conducted to acquire a satellite with a microwave imager, including ground system integration, data dissemination, and ground processing software. The program office stated the prime contractor is currently engaged in system design.

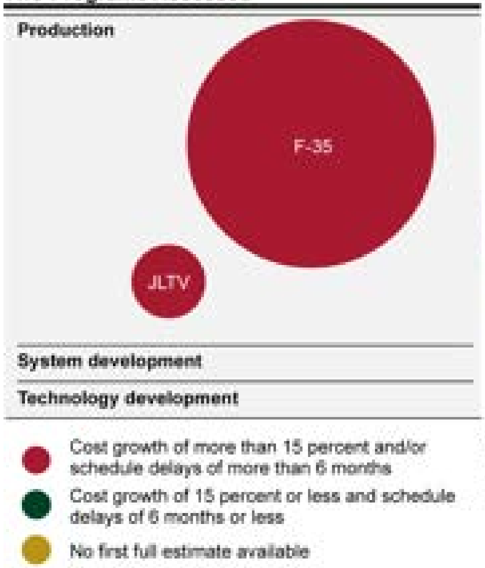
Joint DOD-wide Program Assessments

We completed individual assessments on two of the five “joint” or DOD-wide current and future major defense acquisition programs—the F-35 Lighting II and Joint Light Tactical Vehicle (JLTV) programs. We found that DOD currently estimates a need of almost $239 billion in funding to complete the acquisition of these two programs. We also compared these two programs’ first full estimates of cost and schedule with their current estimates and found that:

- net cost growth exceeds $115 billion, all of which occurred more than 5 years ago and is attributable to the F-35 Lightning II program, and which constitutes a 44 percent increase over initial estimates, and
- program schedule delays average approximately 41 months.

While neither of these programs fully satisfied all applicable knowledge-based best practices at the time the knowledge points were reached, the F-35 Lightning II program ultimately completed all the activities associated with the best practices we assess.

Acquisition Phase and Size of the Two Programs Assessed



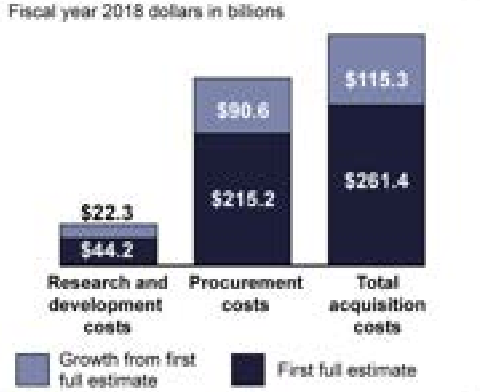
Note: Bubble size is based on each program's currently estimated future funding needed.

Currently Estimated Acquisition Costs for the Two Programs Assessed

Fiscal year 2018 dollars in billions

Cost and Schedule Growth on Two Programs in the Current Portfolio

Fiscal year 2018 dollars in billions



Average acquisition cycle time (in months)

Note: In addition to research and development and procurement costs, total acquisition cost includes acquisition related operation and maintenance and system-specific military construction costs.

Summary of Knowledge Attained to Date for Programs Beyond System Development Start

Program common name	Knowledge Point (KP) 1 Resources and requirements match: At KP1	KP1: Current Status	Knowledge Point 2 Product design is stable: At KP2	KP2: Current Status	Knowledge Point 3 Manufacturing processes are mature: At KP3	KP3: Current Status
F-35 JSF	○	●	○	●	○	●
JLTV	○	●	○	●	○	○

● All applicable knowledge practices completed
○ One or more applicable knowledge practices were not completed
N/A Knowledge practice is not applicable
- - - Information not available for all applicable knowledge practices

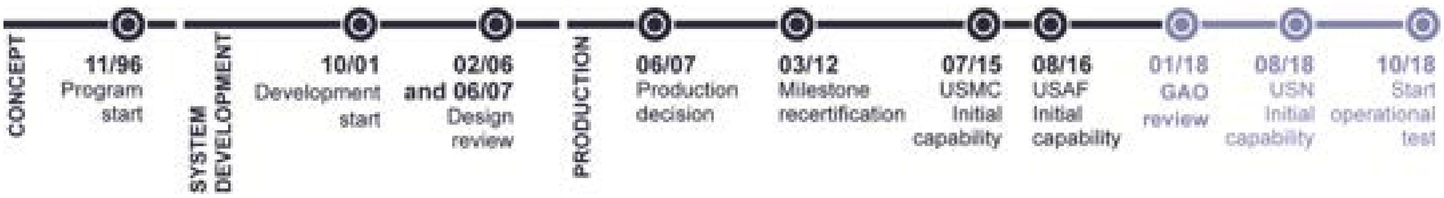
Source: GAO analysis of DOD data. | GAO-18-360SP

Joint DOD-wide Program Assessments

Source: © 2016 Lockheed Martin.

F-35 Lightning II (F-35)

DOD is developing and fielding a family of fifth generation strike fighter aircraft, integrating stealth technologies with advanced sensors and computer networking capabilities for the United States Air Force, Marine Corps, and Navy, eight international partners, and three foreign military sales customers. The family is comprised of three aircraft variants. The Air Force's F-35A variant will complement its F-22A fleet and is expected to replace the air-to-ground attack capabilities of the F-16 and A-10. The Marine Corps' F-35B variant will replace its F/A-18 and AV-8B aircraft. The Navy's F-35C variant will complement its F/A-18E/F aircraft.



Program Essentials

Program office: Arlington, VA

Prime contractors: Lockheed Martin and Pratt & Whitney

Contract types: Fixed-price incentive/cost-plus-incentive-fee (aircraft low-rate initial production)

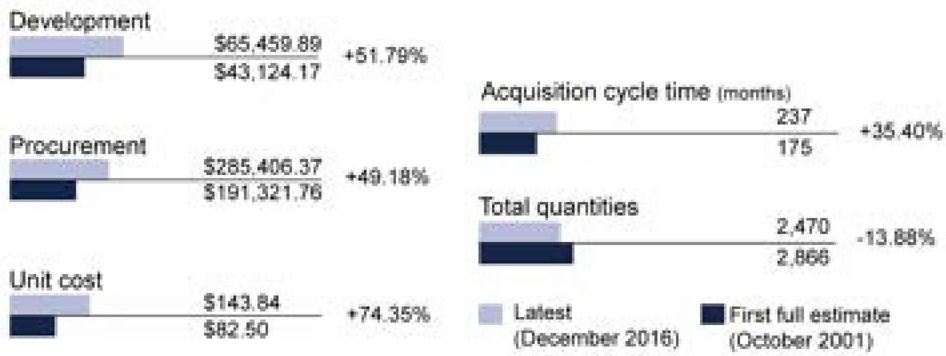
Fixed-price incentive/cost-plus-incentive fee (engine low-rate initial production)

Next major milestone: F-35C initial capability (August 2018)

Program Performance

(Charts not to scale)

(fiscal year 2018 dollars in millions)



Total quantities comprise 14 development quantities and 2,456 procurement quantities.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	○	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	○	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	○	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	●
• Demonstrate critical processes on a pilot production line	○	●
• Test a production-representative prototype in its intended environment	○	●

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

F-35 Program

Technology Maturity and Design Stability

All of the F-35 program's critical technologies are mature and designs for each of the three aircraft variants are stable. However, in 2013, the program deferred a critical technology: the prognostics and health management system, which is part of the Autonomic Logistics Information System (ALIS). The program office is still facing challenges in delivering ALIS capabilities, for all the variants. The program also continues to address deficiencies with other, non-critical technologies, such as the next-generation helmet, which can produce a "glow" effect on the visor making night landings on a carrier difficult, and continues to analyze potential solutions to the excessive vibrations that F-35C pilots currently experience during catapult launch from aircraft carriers. More recently, the program discovered that the F-35 engine's main fuel throttle valve can cause excessive thrust, causing the aircraft to move suddenly and without stopping until the engine was shut down. According to the program office, they are in the process of implementing hardware and software changes to resolve the problem.

Although the aircraft designs were not stable at their critical design reviews in 2006 and 2007, the program office has since released all baseline engineering drawings. Officials continue to identify and address technical risks, some of which are specific to individual variants of the F-35. For example, the contractor reported they are implementing design changes to address deficiencies with the tires of the F-35B, the Marine Corps' aircraft. In addition, pilots have recently reported experiencing symptoms of oxygen deprivation during flights of the F-35A. As a result, test officials grounded the aircraft at one Air Force base in June 2017. Despite the program's review of these cases, it has not been able to identify the root cause of this issue. The program faces the risk of additional design changes to address these issues until developmental testing is completed, and others that could be discovered in operational testing through 2019.

Production Readiness

Aircraft deliveries are increasing slowly and totaled 266 production aircraft as of January 2018. The government temporarily halted deliveries (although not production) for 1 month after identifying corrosion between the aircraft's surface panels and the airframe because the contractor did not apply primer when the panels were attached. A DOD official anticipates that a significant amount of rework will be required on aircraft delivered without the primer; however, the scope of work and the severity of the issue has yet to be fully assessed. Since the start of production, the contractors have refined their production processes. To enable continued improvements and to increase quality, the contractor tracks process control data and other quality indicators. Part shortages and quality control are the top production risks for the prime contractor and its suppliers. For example, part shortages with the radar and canopy are two challenges the program office faces. The contractor is working with suppliers to improve the production process to address these issues as production increases and the need to sustain a growing operational fleet continues.

Other Program Issues

The Air Force and Marine Corps have declared initial operational capability (IOC) for the F-35A and F-35B, respectively. The Navy has scheduled F-35C IOC for August 2018. However, the Navy's criteria to declare IOC includes the completion of operational testing, which is scheduled to end in September 2019. At this time, the Navy has not delayed IOC despite the program's delays to operational testing

Despite numerous delays, partially attributable to software instability, the program plans to complete developmental testing in March 2018. The program has completed flight and mission systems testing partially by combining or removing a significant number of test objectives. The program office is also preparing to start operational testing for the F-35; however, the aircraft that will be used are currently early production models that require upgrades and retrofits before they can be used.

According to the program office, some deficiencies identified during developmental testing will not be fully resolved until the program's planned follow-on modernization period. However, the technical scope and schedule of this modernization period have yet to be finalized. In January 2018, the program office provided Congress with its plans for the transition between the development program and modernization; however, the plans are under review and have yet to be approved.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office stated that it will continue to address deficiencies and incorporate any changes onto aircraft in production and already delivered aircraft. The program office also stated it is on track to start operational testing in late 2018 and has begun necessary modifications to the aircraft that will be used for these tests. Additionally, it said that the F-35C IOC will occur no later than February 2019, per agreement with the Navy. According to the program, although DOD has already approved some requirements for F-35 modernization, the program continues to explore alternative approaches for how to structure any future modernization program.

Source: U.S. Army

Joint Light Tactical Vehicle (JLTV)

The Army and Marine Corps' JLTV is a family of vehicles developed to replace the High Mobility Multipurpose Wheeled Vehicle (HMMWV) for some missions. The JLTV is expected to provide protection for passengers against current and future battlefield threats, increased payload capacity, and improved automotive performance over the up-armored HMMWV. It is designed to be transported by air or ship. Two- and four-seat variants are planned with multiple mission configurations.

Program Essentials

Program office: Harrison Township, MI

Prime contractor: Oshkosh Defense, LLC

Contract type: Firm-fixed-price (production)

Next major milestone: Start of initial operational test and evaluation (February 2018)

Program Performance

(Charts not to scale)

(fiscal year 2018 dollars in millions)

Total quantities comprise 114 development quantities and 56,340 procurement quantities.

Remaining Funding Requirements

(fiscal year 2018 dollars in millions)

Attainment of Product Knowledge

As of January 2018

	Status at	Current Status
Resources and requirements match	**Development Start**	
• Demonstrate all critical technologies are very close to final form, fit and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	●	●
Product design is stable	**Design Review**	
• Release at least 90 percent of design drawings	●	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	**Production Start**	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	○
• Demonstrate critical processes on a pilot production line	●	●
• Test a production-representative prototype in its intended environment	●	●

● Knowledge attained, ○Knowledge not attained, … Information not available, NA Not applicable

JLTV Program

Technology Maturity and Design Stability

Both JLTV critical technologies—underbody blast protection armor and side-kit armor—are fully mature, which the program office attributed to an independent review team within the Office of the Secretary of Defense. These technologies were only approaching maturity at development start, but the program later fully demonstrated both technologies in an operational environment during the competitive system development phase.

During system development, the JLTV program office reviewed three competing designs for prototype vehicles. According to program officials, these reviews were at a level of detail similar to that of a critical design review and found that the three competing contractors had more than 90 percent of design drawings complete, consistent with best practices criteria.

Production Readiness

More than 2 years into production, the JLTV program has yet to demonstrate production readiness using statistical process control data. Prior to entering production, the JLTV program office assessed the manufacturing readiness levels for all three competing contractors. These assessments examined manufacturing process readiness, quality management systems, and production planning activities. Ultimately, the program office found that all three competing contractors demonstrated proven manufacturing processes and procedures, but reached this conclusion without evaluating statistical quality control metrics—an approach inconsistent with best practices.

Program officials stated that the contractor remains unable to provide statistical process control data even after having produced more than 700 vehicles to date because the contractor has historically relied on inspection-based quality procedures for manufacturing vehicles. The program office was also unable to report the number of critical manufacturing processes identified by the contractor because, according to program officials, the information is proprietary. Program officials had previously told us that the contractor would begin collecting production process capability index data during low-rate production and, further, that the government was working with the contractor’s manufacturing personnel to identify critical manufacturing processes. A program official stated that, as the program proceeds from low-rate production to full-rate production, the contractor is evaluating processes on a case-by-case basis in order to determine whether it is financially worthwhile to implement statistical indices or to continue using 100 percent inspections.

Since beginning production, the program has identified vehicle failures resulting in production process engineering changes that must be incorporated into the manufacturing process. According to Defense Contract Management Agency program assessment reports, the resulting retrofit and rework activities have delayed government acceptance of several vehicles. Thirty-three vehicles required retrofits after a vendor used an incorrect material on the subframes. Transmission failures discovered during testing required retrofits to 23 vehicles. According to a Defense Contract Management Agency official, these and other engineering changes must be incorporated into both the overall manufacturing process and previously manufactured JLTVs.

Other Program Issues

Program officials reported that, in March 2016, the JLTV program office exercised a contract option to purchase the JLTV technical data package from Oshkosh. Program officials reported that the purchase provides the government with government purpose rights to the design. After exercising the contract option and receiving some of the technical material, program officials discovered that the engineering drawings were inadequate to facilitate open competition for vehicles to be procured in fiscal year 2021 and beyond. In response, the program office is working with the contractor to improve the quality of the technical data package.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. According to program officials, the JLTV program remains on track for a fiscal year 2019 full-rate production decision. The program stated that JLTV had demonstrated low-rate production readiness and has capability in place to begin full-rate production. The program said that, in support of full-rate production, it is conducting additional analyses of production readiness. The program pointed out that JLTV is manufactured on the same production line as the U.S. Army’s medium and heavy tactical wheeled vehicles and that a retrofit program ensures design changes identified during test will be incorporated prior to first vehicle fielding.

The program said it will have a complete technical data package to support a fiscal year 2021 competition and that, in the meantime, review processes exist to identify current JLTV deficiencies that must be corrected prior to acceptance of low-rate production vehicles. According to the program, validation processes are in place to verify the technical data against production parts and manufacturing processes.

Agency Comments

We provided a draft of this report to DOD for comment. In its comments, reproduced in appendix VII, DOD generally concurred with our observations. DOD also provided us with technical comments, which we incorporated as appropriate.

In its comments, DOD stated that our report shows that the acquisition reform initiatives started in 2010 have resulted in measurable improvements. Specifically, DOD stated that it was encouraged by our observations that it has improved the cost performance of recent programs while also expanding its total acquisition portfolio size and cost. DOD further noted that it remains committed to reducing the costs and time required to deliver weapon systems to warfighters.

DOD also identified plans to increase investments aimed at maintaining technology superiority over adversaries. Further, DOD stated that the separation of the Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics into the Offices of the Under Secretary of Defense for Acquisition and Sustainment and Under Secretary of Defense for Research and Engineering represents a major shift in how DOD develops and procures weapon systems.

We are sending copies of this report to the appropriate congressional committees and offices; the Secretary of Defense; the Secretaries of the Army, Navy, and Air Force; and the Director of the Office of Management and Budget. In addition, the report will be made available at no charge on the GAO website at http://www.gao.gov.

If you are your staff have any questions concerning this report, please contact me at (202) 512-4841. 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 VIII.

Shelby S. Oakley
Director, Contracting and National Security Acquisitions

List of Committees

The Honorable John McCain
Chairman
The Honorable Jack Reed
Ranking Member
Committee on Armed Services
United States Senate

The Honorable Richard Shelby
Chairman
The Honorable Richard J. Durbin
Ranking Member
Subcommittee on Defense
Committee on Appropriations
United States Senate

The Honorable Mac Thornberry
Chairman
The Honorable Adam Smith
Ranking Member
Committee on Armed Services
House of Representatives

The Honorable Kay Granger
Chairwoman
The Honorable Peter Visclosky
Ranking Member
Subcommittee on Defense
Committee on Appropriations
House of Representatives

Appendix I: Major Defense Acquisition Programs' Individual Subcontracting Reports in the Electronic Subcontracting Reporting

Table 11 shows the number of prime contractors for the programs we assessed where an individual subcontracting report is reported as accepted during 2017 in the Electronic Subcontracting Reporting System (eSRS). We reviewed this information for 86 major defense acquisition programs included in our assessment that reported prime contract information in their December 2016 Selected Acquisition Report (SAR) submissions. The government uses individual subcontracting reports from eSRS as one method of monitoring small business participation, as this tool includes information on contractors' performance against small business subcontracting goals. There are multiple reasons why a prime contractor may not have an accepted subcontracting report in eSRS. For example, some contractors may have pending or rejected reports within the system as all reports are reviewed prior to acceptance. Not all prime contractors for major defense acquisition programs are required to submit individual subcontracting reports. Instead, some contractors report small business participation at a corporate level as opposed to the program level and this data is not captured in the individual subcontracting reports. In addition, although a prime contractor may be required to submit a report, it may not yet have done so for the period we reviewed.

Table 11: Major Defense Acquisition Programs' Individual Subcontracting Reports in the Electronic Subcontracting Reporting System (eSRS)

Program name	Number of contracts listed in the December 2016 Selected Acquisition Report	Contracts with an accepted individual subcontracting report (as of July 2017)
Advanced Arresting Gear (AAG)	4	3
Amphibious Combat Vehicle Phase 1 Increment 1 (ACV 1.1)	2	2
Advanced Extremely High Frequency (AEHF) Satellite	2	2
AGM-88E Advanced Anti-Radiation Guided Missile (AGM-88E AARGM)	3	3
AH-64E Apache New Build (AH-64E New Build)	2	2
AH-64E Apache Remanufacture (AH-64E Remanufacture)	6	5
AIM-9X Block II Sidewinder (AIM-9X Blk II)	5	4
Air and Missile Defense Radar (AMDR)	1	1
Airborne and Maritime/Fixed Station (AMF)	0	0
Armored Multi-Purpose Vehicle (AMPV)	1	1
AIM-120 Advanced Medium Range Air-to-Air Missile (AMRAAM)	4	2
Airborne Warning and Control System Block 40/45 Upgrade (AWACS Blk 40/45 Upgrade)	1	1
B-2 Defensive Management System Modernization (B-2 DMS-M)	1	1

Program name	Number of contracts listed in the December 2016 Selected Acquisition Report	Contracts with an accepted individual subcontracting report (as of July 2017)
B61 Mod 12 Life Extension Program Tailkit Assembly (B61 Mod 12 LEP TKA)	2	1
C-130J Hercules Transport Aircraft (C-130J)	4	4
C-5 Reliability Enhancement and Re-engining Program (C-5 RERP)	1	1
Cooperative Engagement Capability (CEC)	5	1
CH-47F Improved Cargo Helicopter (CH-47F)	1	1
CH-53K Heavy Lift Replacement Helicopter (CH-53K)	2	1
Chemical Demilitarization-Assembled Chemical Weapons Alternatives (Chem Demil-ACWA)	2	2
Common Infrared Countermeasure (CIRCM)	1	1
Combat Rescue Helicopter (CRH)	1	1
Gerald R. Ford Class Nuclear Aircraft Carrier (CVN 78)	6	4
DDG 1000 Zumwalt Class Destroyer (DDG 1000)	2	2
DDG 51 Arleigh Burke Class Guided Missile Destroyer (DDG 51)	5	5
E-2D Advanced Hawkeye Aircraft (E-2D AHE)	5	5
EA-18G Growler Aircraft (EA-18G)	6	6
Evolved Expendable Launch Vehicle (EELV)	8	2
Enhanced Polar System (EPS)	1	1
F-15 Eagle Passive Active Warning Survivability System (F-15 EPAWSS)	1	0
F-22 Increment 3.2B Modernization (F-22 Inc 3.2B Mod)	1	1
F-35 Lightning II Program (F-35)	6	5
Family of Advanced Beyond Line-of-Sight Terminals (FAB-T)	2	1
Ground/Air Task Oriented Radar (G/ATOR)	3	3
Global Broadcast Service (GBS)	1	1
Guided Multiple Launch Rocket System/Guided Multiple Launch Rocket Sys Alt Warhead (GMLRS/GMLRS AW)	5	5
Global Positioning System III (GPS III)	2	2
H-1 Upgrades (4BW/4BN) (H-1 Upgrades)	6	3
HC/MC-130 Recapitalization Aircraft (HC/MC-130 Recap)	1	1
Integrated Air and Missile Defense (IAMD)	0	0
Intercontinental Ballistic Missile Fuze Modernization (ICBM Fuze Mod)	1	0
Integrated Defensive Electronic Countermeasures (IDECM) Block 4	2	1
Infrared Search and Track (IRST)	2	1
Joint Air-to-Ground Missile (JAGM)	1	0
Joint Air-to-Surface Standoff Missile (JASSM)	3	2

Program name	Number of contracts listed in the December 2016 Selected Acquisition Report	Contracts with an accepted individual subcontracting report (as of July 2017)
Joint Direct Attack Munition (JDAM)	2	1
Joint Light Tactical Vehicle (JLTV)	1	1
Joint Precision Approach and Landing System Increment 1A (JPALS Inc 1A)	1	0
Joint Tactical Radio System Handheld, Manpack, and Small Form Fit Radios (JTRS HMS)	7	5
KC-130J Transport Aircraft (KC-130J)	4	3
KC-46 Tanker Modernization Program (KC-46A)	4	3
Littoral Combat Ship (LCS)	2	2
Littoral Combat Ship - Mission Modules (LCS Packages)	3	1
LHA 6 America Class Amphibious Assault Ship (LHA 6)	2	2
LPD 17 San Antonio Class Amphibious Transport Dock (LPD 17)	1	1
M88A2 Heavy Equipment Recovery Combat Utility Lift Evacuation System (M88A2 HERCULES)	1	1
Military Global Positioning System (GPS) User Equipment Increment 1 (MGUE Inc 1)	3	2
MH-60R Multi-Mission Helicopter (MH-60R)	3	2
Multifunctional Information Distribution System (MIDS)	4	4
MQ-1C Gray Eagle Unmanned Aircraft System (MQ-1C Gray Eagle)	3	3
MQ-4C Triton Unmanned Aircraft System (MQ-4C Triton)	2	2
MQ-8 Fire Scout	1	0
MQ-9 Reaper Unmanned Aircraft System (MQ-9 Reaper)	3	1
Mobile User Objective System (MUOS)	0	0
Next Generation Jammer Increment 1 (NGJ Inc 1)	2	1
Navy Multiband Terminal (NMT)	2	2
OASuW Inc 1 (LRASM)	2	2
Next Generation Operational Control System (GPS OCX)	1	1
P-8A Poseidon Multi-Mission Maritime Aircraft (P-8A)	3	2
Patriot Advanced Capability-3 Missile Segment Enhancement (PAC-3 MSE)	3	2
M109A7 Family of Vehicles (M109A7 FOV)	2	2
Space Based Infrared System High (SBIRS High)	1	1
Small Diameter Bomb Increment II (SDB II)	3	2
Standard Missile-6 (SM-6)	2	2
Space Fence Ground-Based Radar System Increment 1	1	1
SSBN 826 Columbia Class Submarine(SSBN 826)	1	1
Ship to Shore Connector Amphibious Craft (SSC)	1	1

Program name	Number of contracts listed in the December 2016 Selected Acquisition Report	Contracts with an accepted individual subcontracting report (as of July 2017)
SSN 774 Virginia Class Submarine (SSN 774)	2	2
Tactical Tomahawk RGM-109E/UGM 109E Missile (TACTOM)	2	1
Trident II (D-5) Sea-Launched Ballistic Missile UGM 133A (Trident II Missile)	10	6
UH-60M Black Hawk Helicopter (UH-60M Black Hawk)	1	1
V-22 Osprey Joint Services Advanced Vertical Lift Aircraft (V-22)	4	3
VH-92A Presidential Helicopter Replacement Program	1	1
Wideband Global SATCOM (WGS)	1	1
Warfighter Information Network-Tactical Increment 2 (WIN-T Inc 2)	1	1
Warfighter Information Network-Tactical Increment 3 (WIN-T Inc 3)	1	0
Totals	**215**	**161**

Source: GAO analysis of Department of Defense (DOD) and eSRS data. | GAO-18-360SP

Appendix II: Objectives, Scope, and Methodology

This report includes observations on (1) the cost and schedule performance of the Department of Defense's (DOD) 2017 portfolio of 86 major weapon programs, (2) implementation of key acquisition reform initiatives within 57 current and future programs, and (3) the knowledge that 57 current and future programs attained at key decision points in the acquisition process.

Analysis of Portfolio Cost and Schedule Performance

To develop our 10 observations on the cost and schedule of DOD's 2017 portfolio of current major defense acquisition programs, we obtained and analyzed cost, quantity, and schedule data from Selected Acquisition Reports (SAR) and other information in the Defense Acquisition Management Information Retrieval system, referred to as DAMIR. We entered this data into a database and verified that the data was entered correctly. We converted all cost information to fiscal year 2018 dollars using conversion factors from the DOD Comptroller's National Defense Budget Estimates for Fiscal Year 2018 (table 5-9).

To assess the reliability of the SAR data, we reviewed our previous assessment and DOD officials' responses regarding any changes to DAMIR's data quality control procedures. We determined that the SAR data and the information retrieved from DAMIR were sufficiently reliable for the purposes of this report. Our assessment includes comparisons of cost and schedule changes over the past year, 5 years, and from baseline estimates which utilize SAR data from December 2016, December 2015, December 2011, and from the programs' initial SAR submissions.

We also analyzed the data to determine the number of programs in each portfolio year. In general, we refer to the 86 major defense acquisition programs with SARs dated December 2016 as DOD's 2017 or current portfolio and use a similar convention for prior year portfolios. We retrieved data on research, development, test, and evaluation; procurement; military construction; acquisition operation and maintenance; total acquisition cost; and schedule estimates for the 86 programs in the 2017 portfolio.

The Missile Defense Agency's Ballistic Missile Defense System and its elements are excluded from all analyses as they do not have an integrated long-term baseline, which prevents us from assessing the program's cost progress or comparing it to other major defense acquisition programs.

For our first observation, we compared the 2017 portfolio with the programs that issued SARs in December 2015 (2016 portfolio) to identify the programs that exited and entered the current portfolio, the total cost and number of programs in the current portfolio compared to previous years, and the total cost and schedule change in the current portfolio over the past year.

We then divided the programs into percent cost change categories based on the percent change in total acquisition cost they experienced over the past year. We then totaled the number of programs in each category and the total cost change of the programs in each category.

For our second observation, in order to determine whether programs experienced an increase or decrease in buying power over the past year, we used data on the programs' number of procurement units, procurement cost changes, and average procurement unit costs.

We calculated cost change "due" to quantity changes as the change in quantity over the last year multiplied by the average procurement unit cost for the program a year ago. We calculated cost change "not due" to quantity changes as the current acquisition quantity times the change in average per unit costs. In practice, changes in quantity will often affect per unit cost—as discussed in this appendix—so this is more precisely described as "Cost change due to change in quantity assuming no change in average procurement unit cost" and "Cost change due to change in average procurement unit cost." If changes in quantity affect per unit cost, those changes will appear in the cost change "not due" to quantity changes. We first calculated the amount of procurement cost growth attributable to quantity changes. To do this, we multiplied any change in quantity by the average procurement unit cost for the program a year ago. The resulting dollar amount is considered a change due solely to shifts in the number of units procured and may overestimate the amount of change expected when quantities increase. Additionally, it could also underestimate the expected change when quantities decrease as it does not account for other effects of quantity changes on procurement such as gain or loss of learning in production that could result in changes to unit cost over time or the use or absence of economic orders of material. However, these changes are accounted for as part of the change in cost not due to quantities.

For the third observation, we aggregated funding stream data for the total planned investment of each portfolio from DAMIR for each year since 2007 to determine any trends. We determined the yearly totals for research and development, procurement, and total acquisition cost. To distinguish the funding already invested from the funding remaining that is needed to complete the programs in each portfolio since 2007, we used funding stream data obtained from DAMIR for each December SAR submission for the years 2006 (2007 portfolio) through 2016 (2017 portfolio). We define funding invested as all funding that has been provided to the programs in the fiscal year of the annual SAR submission (this includes fiscal year 2017 for the December 2016 submission) and earlier, while funding remaining is all the amounts that will be provided in the fiscal years after the annual SAR submission (fiscal year 2018 and later for the December 2016 submission).

For our fourth observation, we evaluated program performance against high-risk criteria discussed by DOD, the Office of Management and Budget, and GAO. We calculated how many programs had less than a 2 percent increase in total acquisition cost over the past year, less than a 10 percent increase over the past 5 years, and less than a 15 percent increase from baseline estimates using data from SARs. We calculated the percentage of programs meeting each of these high-risk criteria for the 2012 through 2017 timeframe to identify any changes. For programs with multiple sub-programs presented in the SARs, we calculated the net effect of the sub-programs to reach an aggregate program result.

For our fifth observation, we determined the total acquisition-related cost growth on defense acquisition programs in the current portfolio from all previous SAR estimates. To do this, we collected data from programs' annual SARs. In addition, we analyzed programs' cost growth between three intervals based on the program's knowledge points: development start to critical design review, critical design review to production start, and after the production decision. We then calculated the total cost growth for the entire portfolio within these intervals.

For our sixth observation, we determined which programs were initiated after December 4, 2009, the date on which DOD implemented selected requirements of the Weapon Systems Acquisition Reform Act of 2009 (WSARA), and what percentage of the portfolio's total acquisition cost was allocated to these programs as well as the remainder of the portfolio and the F-35 program.

For our seventh observation, we determined which programs were initiated after December 4, 2009, the date on which DOD implemented selected requirements of WSARA. We then examined these programs' cost and schedule changes over the past year as a group and compared them with the group of programs initiated after December 4, 2009, in the remainder of the 2017 portfolio.

For the eighth observation, we identified the development, procurement, and other acquisition funding (military construction and acquisition operations and maintenance) and the change in these over the past year. We identified the specific programs with the largest total acquisition cost increases in terms of cost and percentage. Additionally, we used the same identification factors to assess the 25 post-WSARA programs—programs which were initiated in or after 2010—and 61 pre-WSARA programs—those initiated prior to 2010—separately in terms of cost and schedule changes. We divided these programs into percent cost change categories based on the percent change in total acquisition cost, both due to quantity changes and not due to quantity change, they experienced over the past year. We then totaled the number of programs in each category—pre-2010 and since 2010 groups—and the total cost change of the programs in each category.

For our ninth observation, we performed a buying power analysis repeating the same steps as detailed in the second observation above, but separated our analysis into the post-2010 group of programs and pre-2010 group of programs. We did this so we could compare the buying power difference between the two groups of programs.

For our 10th observation, we took our total acquisition-related cost growth between the knowledge points analysis, which we detailed in observation five above, and separated the analysis into the subgroup of programs initiated since 2010 and the subgroup of program initiated prior to 2010. We did this so we could compare the difference in acquisition cost growth between the knowledge point intervals for both groups of programs.

Analysis of Acquisition Initiatives

To develop observations on how DOD is implementing acquisition reforms, we reviewed the DOD Instruction 5000.02, the Weapon Systems Acquisition Reform Act of 2009 (WSARA), and the September 19, 2014, Under Secretary of Defense for Acquisition, Technology, and Logistics “Better Buying Power 3.0 Interim Release” as well as earlier related memorandums. We analyzed questionnaire data received from the 45 current and 12 future major defense acquisition programs in our assessment to determine the extent to which acquisition reforms have been implemented. Based on the questionnaire responses, we determined which programs have established affordability constraints, whether they were meeting those constraints, and, for current programs, examined the average total cost growth of programs with these constraints compared to those without. We tallied programs that conducted “should-cost” analyses the amount of savings identified, savings to date and future expected savings. We also identified the most common practices these programs used to realize their savings. We also analyzed whether programs are planning for competition, both prior to and after development as well as throughout the acquisition life cycle. Further, for all 57 programs, we identified the programs that competitively awarded development, test, or production contracts and those that awarded non-competitive contracts and determined the cost changes not due to quantity changes experienced by the programs on average in each group.

Analysis of Selected DOD Programs Using Knowledge-Based Criteria and Analysis of Concurrency in Those Programs’ Developmental Test and Production Schedules

To collect data from current and future major defense acquisition programs—including cost and schedule estimates, technology maturity, and planned implementation of acquisition reforms—we distributed two electronic questionnaires—one questionnaire for the 45 current programs and a slightly different questionnaire for the 12 future programs. Both of the questionnaires were web-based so that respondents could respond and submit their answers online. We received responses from all of the programs we assessed from October 2017 to January 2018. To ensure the reliability of the data collected through the data collection instrument and our questionnaires, we took a number of steps to reduce measurement error and non-response error.

These steps included conducting three pretests of the future major defense acquisition program questionnaire and three pretests for the current major defense acquisition program questionnaire prior to distribution to ensure that our questions were clear, unbiased, and consistently interpreted. Our pretests covered each branch of the military to better ensure that the questionnaires could be understood by officials within each branch. We determined that the data from the SARs and DAMIR were sufficiently reliable for the purposes of this report.

Our analysis of how well programs are adhering to a knowledge-based acquisition approach focuses on 45 major defense acquisition programs that are mostly in development or the early stages of production. To assess the knowledge attained by key decision points (system development start or detailed design contract award for shipbuilding programs, critical design review or lead ship fabrication start for shipbuilding programs, and production start), we collected data from program offices about their knowledge at each point.

We also provide information on how much knowledge was obtained at key decision points by programs that accomplished these previously. We also included observations on the knowledge that the 12 future programs expect to obtain before starting development. We did not validate the data provided by the program offices, but reviewed the data and performed various checks to determine that they were reliable for our purposes. Where we discovered discrepancies, we clarified the data accordingly. In addition, we determined the percentage of programs which previously met each knowledge-based acquisition practice for the 2017 portfolio of programs as well as for the 2016 portfolio and determined whether the trend from year to year was improving (percentage change was increasing greater than 5 percentage), was declining (percentage change was decreasing greater than 5 percent) or was negligible (percentage change was between 0 to 5 percent).

For programs that have passed a key decision point and have since been restructured, we will continue to assess them against their original cost and schedule estimates at that milestone or decision point, such as development start. We will not reassess a program at milestones that have already been reached if a program is repeating a key decision point or milestone such as milestone B. We will keep our original assessment of the program's knowledge attained at the original milestone. However, we will change a future milestone date if that milestone had not yet been reached and assess the program for its implementation of our best practices at that point in time.

We performed an exploratory statistical analysis that examined our identified knowledge-based acquisition practices and select programs' cost and schedule changes. We focused the analysis on the 15 non-shipbuilding major defense acquisition programs (MDAP) that prior to this assessment completed each of the three knowledge points within the acquisition process (i.e., completed development, held a critical design review, and started production). Our statistical analysis compared average cost and schedule changes for those programs that had implemented eight key knowledge-based acquisition practices by the time they reached knowledge points 1 through 3, compared to those programs that did not complete the best practices at each knowledge point. To ensure a minimally reliable estimate of the average in each group, we limited our analysis to those knowledge-based acquisition practices for which at least three programs had engaged in the practice, and at least three programs had not engaged in the practice. Although we sought to assess the statistical significance of demonstrating technologies to form, fit, and function within a realistic environment, we observed that only one program in the sample demonstrated this level of technology maturity before it started development. This one program provided an insufficient basis to determine whether this best practice corresponded with lower cost and schedule growth. We assessed the statistical significance of the observed differences between the groups at the 95 percent confidence level.[1] With such a small sample of MDAPs, our estimates are fairly imprecise and do not meet normality assumptions. In addition, we observed three knowledge-based acquisition practices that potentially had higher cost and schedule outcomes, but did not attain statistical significance at the 95 percent confidence level.

To assess programs' developmental testing and production concurrency, we identified the programs—among those we included in our assessment—with production start dates. We used the questionnaire responses from those programs to identify the dates for the start and end of developmental testing, compared those dates to the timing of each program's production decision, and determined the number of months of concurrency, if any, of developmental testing done after production start. We then divided the programs with concurrency into one group and the programs without any identified concurrency into another and determined the average amount of cost change not due to quantity changes for each group.

To examine programs' software development efforts, we identified the dates reported by programs for their software and hardware integration and compared those dates to each program's production start date to assess each program's degree of software development and production concurrency.

To examine when programs' were declaring initial operational capability compared to finishing their operational testing, we identified programs initial operational capability and start and end dates of their operational testing. We determined whether the initial operational capability date was before, during or after its testing dates. Based on our determination, we summed and analyzed what percent of programs were in each category. For some programs, either one or both of these dates were not available

[1]Statistical significance at the 95 percent confidence level indicates that the chances of observing a statistical difference as large or larger as observed by chance, if no difference existed, is less than 5 percent.

The 57 current and future programs included in our assessment were in various stages of the acquisition cycle, and not all of the programs provided information on knowledge obtained at each point. Programs were not included in our assessments at key decision points if relevant data were not available. Our analysis of knowledge attained at each key point includes factors that we have previously identified as underpinning a knowledge-based acquisition approach, including holding early systems engineering reviews, testing an integrated prototype prior to the design review, using a reliability growth curve, planning for manufacturing, and testing a production-representative prototype prior to making a production decision. Additional information on how we collect these data is found in the product knowledge assessment section of this appendix. See also appendix III for a list of the practices that are associated with a knowledge-based acquisition approach.

Individual Assessments of Weapon Programs

This report presents individual assessments of 57 current and future weapon programs. A table listing these assessments is found in appendix VIII. Of our 57 total assessments, 42 are captured in a two-page format discussing technology, design, and manufacturing knowledge obtained and other program issues. These two-page assessments are of current major defense acquisition programs, most of which are in development or early production. The remaining 15 assessments are described in a one-page format that describes their current status. Those one-page assessments include (1) 12 future major defense acquisition programs and (2) three major defense acquisition programs that are well into production, but planning to introduce new increments of capability—specifically, the Navy's DDG 51 Arleigh Burke Class Destroyer, Flight III; P-8A Poseidon Multi-Mission Maritime Aircraft Increment 3; and SSN 774 Virginia Class Submarine, Block V.

For presentation purposes we grouped the individual assessments by lead service—Army, Navy and Marine Corps, Air Force, and DOD-wide—and inserted a lead service separator page at the start of each grouping. These four separator pages summarize information about the acquisition phase, current estimated funding needs, cost and schedule growth, and product knowledge attained that is provided in the one- and two-page assessments. We report cost and schedule growth in the separator pages in a manner that is consistent with how it is reported and described elsewhere in the report. Estimates of "funding needed to complete" in the separator pages are based on all amounts that will be provided in fiscal year 2018 and later. For some future major defense acquisition programs, the estimates of funding needed represents only those amounts provided through fiscal year 2022 and are not the full amount needed to complete the acquisition.

Over the past several years, DOD has revised policies governing weapon system acquisitions and changed the terminology used for major acquisition events. To make DOD's acquisition terminology more consistent across our individual program assessments, we standardized the terminology for key program events. For most individual programs in our assessment, "development start" refers to the initiation of an acquisition program as well as the start of either engineering and manufacturing development or system development. This generally coincides with DOD's milestone B. A few programs in our assessment have a separate "program start" date, which begins a pre–system development phase for program definition and risk-reduction activities. This "program start" date generally coincides with DOD's former terminology for milestone I or DOD's current milestone A, which denotes the start of technology maturation and risk reduction. The "production decision" generally refers to the decision to enter the production and deployment phase, typically with low-rate initial production. The "initial capability" refers to the initial operational capability—sometimes called first unit equipped or required asset availability. For shipbuilding programs, the schedule of key program events in relation to acquisition milestones varies for each program. Our work on shipbuilding best practices has identified the detailed design contract award and the start of lead ship fabrication as the points in the acquisition process roughly equivalent to development start and design review for other programs.

We obtained the information presented in the Program Essentials section of the individual assessments from program office responses to a questionnaire and program office documents. As a result, DOD is the source of the information regarding the identity of the contractors and the contract types. We did not review individual contracts for each system.

For each program we assessed in a two-page format, we present cost, schedule, and quantity data at the program's first full estimate as well as an estimate from either the latest SAR or the program office reflecting 2017 data where they were available. The first full estimate is generally the cost estimate established at milestone B—development start; however, for a few programs that did not have such an estimate, we used the estimate at milestone C—production start—instead. For shipbuilding programs, we used their planning estimates if those estimates were available. For systems for which a first full estimate was not available, we only present the latest available estimate of cost and quantities. For the other programs assessed in a one-page format, we present the latest available estimate of cost and quantity from the program office.

For each program we assessed, all cost information is presented in fiscal year 2018 dollars. We converted cost information to fiscal year 2018 dollars using conversion factors from the DOD Comptroller's National Defense Budget Estimates for Fiscal Year 2018 (table 5-9). We have depicted only the program's main elements of acquisition cost—research and development and procurement. However, the total program cost also includes military construction and acquisition-related operation and maintenance costs. Because of rounding and these additional costs, in some situations, total cost may not match the exact sum of the research and development and procurement costs. The program unit costs are calculated by dividing the total program cost by the total quantities planned. These costs are often referred to as program acquisition unit costs. In some instances, the data were not applicable, and we annotate this by using the term "not applicable (NA)." The quantities listed refer to total quantities, including both procurement and development quantities.

The schedule assessment for each program is based on acquisition cycle time, defined as the number of months between program start and the achievement of initial operational capability or an equivalent fielding date. In some instances the data were not yet available, and we annotate this by using the term "to be determined (TBD)" or "NA."

The information presented in "Remaining Funding Requirements" is from fiscal year 2018 through completion and draws on information from SARs or on data from the program office. The quantities listed refer only to procurement quantities. Satellite programs, in particular, produce a large percentage of their total operational units as development quantities, which are not included in the quantity figure.

The intent of these comparisons is to provide an aggregate, or overall, picture of a program's history. These assessments represent the sum of the federal government's actions on a program, not just those of the program manager and the contractor. DOD does a number of detailed analyses of changes that attempt to link specific changes with triggering events or causes. Our analysis does not attempt to make such detailed distinctions.

In this year's assessment we also reviewed whether individual subcontracting reports from a program's prime contractor or contractors were accepted on the Electronic Subcontracting Reporting System (eSRS). We reviewed this information for 86 of the major defense acquisition programs included in our assessment using the contract information reported in their December 2016 Selected Acquisition Reports. See appendix IV for a list of the programs we reviewed.

Product Knowledge Data on Individual Two-Page Assessments

In our past work examining weapon acquisition issues and knowledge-based acquisition practices for product development, we have found that leading commercial firms pursue an acquisition approach that is anchored in knowledge, whereby high levels of product knowledge are demonstrated by critical points in the acquisition process. On the basis of this work, we have identified three key knowledge points during the acquisition cycle—system development start, critical design review, and production start—at which programs need to demonstrate critical levels of knowledge to proceed. To assess the product development knowledge of each program at these key points, we reviewed questionnaires submitted by programs; however, not every program had responses to each element of the questionnaire. We also reviewed pertinent program documentation and discussed the information presented on the questionnaire with program officials as necessary.

For our attainment of product knowledge tables, we assessed the programs' current status in implementing the knowledge-based acquisition practices criteria, as well as the programs' progress in meeting the criteria at the time they reached the three key knowledge points during the acquisition cycle—system development start, critical design review, and production start. For programs that have passed a key decision point and have since been restructured, we continue to assess them against their original cost and schedule estimates at that milestone or decision point, such as development start. We have not reassessed a program at milestones that have already been reached if a program is repeating a key decision point or milestone, such as milestone B. We have kept our original assessment of the program's knowledge attained at the original milestone. However, we have changed future milestone dates in instances when the program had not yet reached the affected milestone. In these instances, we assessed the program for its implementation of our knowledge-based acquisition practices criteria at that point in time. To assess a program's readiness to enter system development, we collected data through the questionnaire on critical technologies and early design reviews. To assess technology maturity, we asked program officials to apply a tool, referred to as technology readiness levels (TRL), for our analysis. The National Aeronautics and Space Administration originally developed TRLs, and the Army and Air

Force science and technology research organizations use them to determine when technologies are ready to be handed off from science and technology managers to product developers. TRLs are measured on a scale from 1 to 9, beginning with paper studies of a technology's feasibility and culminating with a technology fully integrated into a completed product. See appendix VI for TRL definitions. Our knowledge-based acquisition practices work has shown that a TRL 7—demonstration of a technology in its form, fit, and function within a realistic environment—is the level of technology maturity that constitutes a low risk for starting a product development program.[2] For shipbuilding programs, we have recommended that this level of maturity be achieved by the contract award for detailed design.[3] In our assessment, the technologies that have reached TRL 7, a prototype demonstrated in a realistic environment, are referred to as mature or fully mature. Those technologies that have reached TRL 6, a prototype very close to final form, fit, and function demonstrated within a relevant environment, are referred to as approaching or nearing maturity. Satellite technologies that have achieved TRL 6 are assessed as fully mature due to the difficulty of demonstrating maturity in a realistic environment—space. In addition, we asked program officials to provide the date of the system-level preliminary design review. We compared this date to the system development start date.

In most cases, we did not validate the program offices' selection of critical technologies or the determination of the demonstrated level of maturity. We sought to clarify the TRLs in those cases where information existed that raised questions. If we were to conduct a detailed review, we may or may not adjust the critical technologies assessed, their readiness levels demonstrated, or both. It was not always possible to reconstruct the technological maturity of a weapon system at key decision points after the passage of many years. Where practicable, we compared technology assessments provided by the program office to assessments by officials from the Office of the Assistant Secretary of Defense for Research and Engineering.

[2]GAO, *Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes*, GAO/NSIAD-99-162 (Washington, D.C.: July 30, 1999); GAO, *Best Practices: Better Matching of Needs and Resources Will Lead to Better Weapon System Outcomes*, GAO-01-288 (Washington, D.C.: Mar. 8, 2001).

[3]GAO, *Best Practices: High Levels of Knowledge at Key Points Differentiate Commercial Shipbuilding from Navy Shipbuilding*, GAO-09-322 (Washington, D.C.: May 13, 2009).

To assess design stability, we asked program officials to provide the percentage of design drawings completed or projected for completion by the design review, the production decision, and as of our current assessment in the data-collection instrument. In most cases, we did not verify or validate the percentage of engineering drawings provided by the program office. We clarified the percentage of drawings completed in those cases where information that raised questions existed. Completed drawings were defined as the number of drawings released or deemed releasable to manufacturing that can be considered the “build to” drawings. For shipbuilding programs, we asked program officials to provide the percentage of the three-dimensional product model that had been completed by the start of lead ship fabrication, and as of our current assessment. To gain greater insights into design stability, we also asked program officials to provide the date they planned to first integrate and test all key subsystems and components into a system-level integrated prototype. We compared this date to the date of the design review. We did not assess whether shipbuilding programs had completed integrated prototypes.

To assess production maturity, we asked program officials for their Manufacturing Readiness Level (MRL) for process capability and control or to identify the number of critical manufacturing processes and, where available, to quantify the extent of statistical control achieved for those processes as a part of our questionnaire. In most cases, we did not verify or validate the information provided by the program office. We clarified the number of critical manufacturing processes and the percentage of statistical process control where information existed that raised questions. We used a standard called the Process Capability Index, a process-performance measurement that quantifies how closely a process is running to its specification limits. The index can be translated into an expected product defect rate, and we have found it to be a best practice. We also used data provided by the program offices on their MRL for process capability and control, a sub-thread tracked as part of the manufacturing readiness assessment process recommended by DOD, to determine production maturity. We assessed programs as having mature manufacturing processes if they reported an MRL 9 for that sub-thread—meaning that manufacturing processes are stable, adequately controlled, and capable. To gain further insights into production maturity, we asked program officials whether the program planned to demonstrate critical manufacturing processes on a pilot production line before beginning low-rate production. We also asked programs on what date they planned to begin system-level developmental testing of a fully configured, production-representative prototype in its intended environment. We compared this date to the production start date. We did not assess production maturity for shipbuilding programs.

Although the knowledge points provide indicators of potential risks, by themselves they do not cover all elements of risk that a program encounters during development, such as funding instability.

We conducted this performance audit from May 2017 to April 2018, 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: Knowledge-Based Acquisition Practices

Our prior work on best product development practices found that successful programs take steps to gather knowledge that confirm that their technologies are mature, their designs stable, and their production processes are in control. Successful product developers ensure a high level of knowledge is achieved at key junctures in development. We characterize these junctures as knowledge points. The related GAO Products section of this report includes references to the body of work that helped us identify these practices and apply them as criteria in weapon system reviews. Table 12 summarizes these knowledge points and associated practices.

Table 12: Best Practices for Knowledge-based Acquisitions

Knowledge Point 1: Technologies, time, funding, and other resources match customer needs. Decision to invest in product development.
Demonstrate technologies to a high readiness level—Technology Readiness Level 7—to ensure technologies are fit, form, function, and work within a realistic environment[a]
Ensure that requirements for product increment are informed by system-level preliminary design review using system engineering process (such as prototyping of preliminary design)
Establish cost and schedule estimates for product on the basis of knowledge from system-level preliminary design using system engineering tools (such as prototyping of preliminary design)
Constrain development phase (5 to 6 years or less) for incremental development
Ensure development phase fully funded (programmed in anticipation of milestone)
Align program manager tenure to complete development phase
Contract strategy that separates system integration and system demonstration activities
Conduct independent cost estimate
Conduct independent program assessment
Conduct major milestone decision review for development start
Knowledge Point 2: Design is stable and performs as expected. Decision to start building and testing production-representative prototypes.
Complete system critical design review
Complete 90 percent of engineering design drawing packages
Complete subsystem and system design reviews
Demonstrate with system-level integrated prototype that design meets requirements
Complete failure modes and effects analysis
Identify key system characteristics
Identify critical manufacturing processes
Establish reliability targets and growth plan on the basis of demonstrated reliability rates of components and subsystems
Conduct independent cost estimate

Conduct independent program assessment
Conduct major milestone decision review to enter system demonstration
Knowledge Point 3: Production meets cost, schedule, and quality targets. Decision to produce first units for customer.
Demonstrate manufacturing processes on a pilot production line
Build and test and production-representative prototype to demonstrate product in intended environment
Test production-representative prototypes to achieve reliability goal
Collect statistical process control data
Demonstrate that critical processes are capable and in statistical control
Conduct independent cost estimate
Conduct independent program assessment
Conduct major milestone decision review to begin production

Source: GAO │ GAO-18-360SP

[a]DOD policy permits development to start at a technology maturity level commensurate with TRL 6—demonstration of program technology in a relevant environment. Therefore we have assessed programs against this measure as well.

Appendix IV: Comparison of December 2016 and First Full Estimates of Total Acquisition Cost for Programs in the Department of Defense

Table 13 outlines the December 2016 and first full estimates of total acquisition cost (in fiscal year 2018 dollars) for each program in the Department of Defense's (DOD) 2017 portfolio of major weapon programs. For each program, we show the percentage change in total acquisition cost from the first full estimate, as well as over the previous year and 5 years.

Table 13: December 2016 Cost Estimates and First Full Estimates for DOD's 2017 Portfolio of Major Defense Acquisition Programs

Fiscal year 2018 dollars in millions

Program Name	December 2016 estimated total acquisition cost	First full estimate of total acquisition cost	Percentage change in total acquisition cost from first full estimate	Percentage change in total acquisition cost since December 2015	Percentage change in total acquisition cost since December 2011
Advanced Arresting Gear (AAG)	2,090.64	2,070.50	1.0	1.0	1.0
Advanced Extremely High Frequency (AEHF) Satellite	15,276.77	7,048.33	116.7	-0.5	-1.1
AGM-88E Advanced Anti-Radiation Guided Missile (AGM-88E AARGM)	2,784.14	1,771.05	57.2	-0.1	27.9
AH-64E Apache New Build (AH-64E New Build)	1,942.38	2,621.89	-25.9	-15.9	-10.3
AH-64E Apache Remanufacture (AH-64E Remanufacture)	14,093.65	8,012.96	75.9	-2.0	21.0
AIM-9X Block II Sidewinder (AIM-9X Blk II)	3,452.03	4,420.39	-21.9	-11.4	-19.5
Air and Missile Defense Radar (AMDR)	5,707.89	6,184.71	-7.7	3.1	-7.7
Airborne and Maritime/Fixed Station (AMF)	3,321.05	9,021.63	-63.2	-1.8	-23.3
Armored Multi-Purpose Vehicle (AMPV)	11,352.88	11,270.28	0.7	0.5	0.7
AIM-120 Advanced Medium Range Air-to-Air Missile (AMRAAM)	25,176.44	12,094.04	108.2	0.0	-1.5
Airborne Warning and Control System Block 40/45 Upgrade (AWACS Blk 40/45 Upgrade)	2,968.37	3,088.98	-3.9	2.1	-3.9
Amphibious Combat Vehicle (ACV)	1,838.95	1,940.83	-5.2	-5.2	-5.2
B-2 Defensive Management System Modernization (B-2 DMS-M)	2,634.72	2,654.14	-0.7	-0.7	-0.7
B61 Mod 12 Life Extension Program Tailkit Assembly (B61 Mod 12 LEP TKA)	1,247.24	1,446.43	-13.8	-4.6	-13.8
C-130J Hercules Transport Aircraft (C-130J)	17,496.05	1,050.01	1,566.3	-0.9	-0.9
C-5 Reliability Enhancement and Re-engining Program (C-5 RERP)	7,658.26	12,065.28	-36.5	-1.7	-6.0
CH-47F Improved Cargo Helicopter (CH-47F)	16,191.50	3.562.39	354.5	-1.3	3.0
CH-53K Heavy Lift Replacement Helicopter (CH-53K)	28,318.75	18,318.54	54.6	5.8	13.7

Fiscal year 2018 dollars in millions

Program Name	December 2016 estimated total acquisition cost	First full estimate of total acquisition cost	Percentage change in total acquisition cost from first full estimate	Percentage change in total acquisition cost since December 2015	Percentage change in total acquisition cost since December 2011
Chemical Demilitarization-Assembled Chemical Weapons Alternatives (Chem Demil-ACWA)	13,547.63	2,923.24	363.4	18.3	21.8
Columbia Class Ballistic Missile Submarine (SSBN 826)	101,277.54	102,225.52	-0.9	-0.9	-0.9
Combat Rescue Helicopter (CRH)	8,746.84	8,595.45	1.8	0.5	1.8
Common Infrared Countermeasure (CIRCM)	2,690.94	2,666.14	0.9	0.9	0.9
Cooperative Engagement Capability (CEC)	6,455.94	3,256.49	98.2	2.1	10.1
DDG 1000 Zumwalt Class Destroyer (DDG 1000)	24,492.81	38,505.53	-36.4	1.5	6.1
DDG 51 Arleigh Burke Class Guided Missile Destroyer (DDG 51)	128,236.10	16,803.68	663.1	2.5	15.6
E-2D Advanced Hawkeye Aircraft (E-2D AHE)	22,466.61	16,321.76	37.6	0.4	4.8
EA-18G Growler Aircraft (EA-18G)	16,779.94	9,930.79	69.0	-1.8	35.4
Evolved Expendable Launch Vehicle (EELV)	57,889.90	19,224.09	201.1	-4.8	53.6
Enhanced Polar System (EPS)	1,462.66	1,475.73	-0.9	-0.3	-0.9
F-15 Eagle Passive Active Warning Survivability System (F-15 EPAWSS)	2,690.30	4,414.39	-39.3	-39.3	-39.3
F-22 Increment 3.2B Modernization (F-22 Inc 3.2B Mod)	1,530.58	1,657.97	-7.7	-5.5	-7.7
F-35 Lightning II Program (F-35)	355,281.38	236,448.60	50.3	3.6	-1.8
Family of Advanced Beyond Line-of-Sight Terminals (FAB-T)	4,660.68	3,527.77	32.1	1.1	-5.4
MQ-8 (Fire Scout)	2,961.34	2,893.62	2.3	-1.1	3.2
Gerald R. Ford Class Nuclear Aircraft Carrier (CVN 78)	39,661.55	39,359.85	0.8	3.6	3.9
Ground/Air Task Oriented Radar (G/ATOR)	2,916.27	1,621.80	79.8	1.5	79.8
Global Broadcast Service (GBS)	1,366.74	637.21	114.5	-0.1	4.7
Guided Multiple Launch Rocket System/Guided Multiple Launch Rocket Sys Alt Warhead (GMLRS/GMLRS AW)	7,734.43	1,956.41	295.3	10.8	16.0
Global Positioning System III (GPS III)	5,772.47	4,360.81	32.4	-2.0	26.7
Next Generation Operational Control System (OCX)	5,569.33	3,663.35	52.0	25.4	52.0
H-1 Upgrades (4BW/4BN) (H-1 Upgrades)	13,160.23	4,012.79	228.0	-2.6	-5.1
HC/MC-130 Recapitalization Aircraft (HC/MC-130 Recap)	14.419.29	9.254.32	55.8	-1.4	2.3
Handheld, Manpack, and Small Form Fit Radios (HMS)	9,640.89	11,105.50	-13.2	-1.2	4.7
Infrared Search and Track (IRST)	2,213.84	2,226.28	-0.6	-0.6	-0.6
Integrated Air and Missile Defense (IAMD)	7,144	5,563.75	28.4	7.7	12.1

Fiscal year 2018 dollars in millions

Program Name	December 2016 estimated total acquisition cost	First full estimate of total acquisition cost	Percentage change in total acquisition cost from first full estimate	Percentage change in total acquisition cost since December 2015	Percentage change in total acquisition cost since December 2011
Intercontinental Ballistic Missile Fuze Modernization (ICBM Fuze Mod)	1,926.48	1,927.97	-0.1	-1.0	-0.1
Integrated Defensive Electronic Countermeasures (IDECM) Blocks 2/3/4	3,073.14	2,408.84	27.6	-0.6	16.4
Joint Air-to-Ground Missile (JAGM)	5,951.13	5,958.28	-0.1	-0.3	-0.1
Joint Air-to-Surface Standoff Missile Extended Range (JASSM-ER)	4,361.40	2,494.60	74.8	3.7	20.8
Joint Direct Attack Munition (JDAM)	11,330.94	3,782.65	199.6	11.1	48.8
Joint Light Tactical Vehicle (JLTV)	21,369.69	24,931.82	-14.3	2.4	-14.3
Joint Precision Approach and Landing System (JPALS)	1,896.58	1,120.00	69.3	-5.4	73.8
KC-130J Transport Aircraft (KC-130J)	9,826.34	10,494.26	-6.4	-0.4	-7.2
KC-46 Tanker Modernization Program (KC-46A)	41,171.84	48,488.25	-15.1	-7.5	-14.5
Littoral Combat Ship (LCS)	20,814.18	2,482.76	738.3	-23.4	-40.3
Littoral Combat Ship - Mission Modules (LCS Packages)	7,291.28	7,250.26	0.6	0.7	0.6
LHA 6 America Class Amphibious Assault Ship (LHA 6)	10,362.44	3,518.46	194.5	1.7	-5.2
LPD 17 San Antonio Class Amphibious Transport Dock (LPD 17)	23,371.75	12,958.90	80.4	6.6	14.0
M109A7 Family of Vehicles (M109A7 FOV)	7,494.61	7,399.44	1.3	-0.8	1.5
M88A2 Heavy Equipment Recovery Combat Utility Lift Evacuation System (M88A2 Hercules)	3,280.91	3,330.18	-1.5	-1.5	-1.5
MH-60R Multi-Mission Helicopter (MH-60R)	14,845.07	6,125.08	142.4	-0.8	-7.2
Military GPS User Equipment (MGUE) Increment 1	1,178.80	1,535.80	-23.2	-23.2	-23.2
MQ-1C Gray Eagle Unmanned Aircraft System (MQ-1C Gray Eagle)	6,064.89	1,123.25	439.9	10.6	18.9
MQ-4C Triton Unmanned Aircraft System (MQ-4C Triton)	15,509.92	14,214.53	9.1	15.9	8.9
MQ-9 Reaper Unmanned Aircraft System (MQ-9 Reaper)	13,042.91	2,917.49	347.1	6.4	-2.8
Multifunctional Information Distribution System (MIDS)	5,205.16	1,442.90	260.7	1.7	40.6
Mobile User Objective System (MUOS)	6,982.89	7,436.50	-6.1	-7.5	-10.2
Navy Multiband Terminal (NMT)	2,439.52	2,567.96	-5.0	3.4	19.1
Next Generation Jammer Increment 1 (NGJ Inc 1)	7,762.64	7,749.66	0.2	0.2	0.2
Offensive Anti-Surface Warfare Increment 1 (OASuW Inc 1)	1,632.85	1,558.80	4.8	4.8	4.8
P-8A Poseidon Multi-Mission Maritime Aircraft (P-8A)	35,044.89	34,336.44	2.1	2.6	-3.1

Fiscal year 2018 dollars in millions

Program Name	December 2016 estimated total acquisition cost	First full estimate of total acquisition cost	Percentage change in total acquisition cost from first full estimate	Percentage change in total acquisition cost since December 2015	Percentage change in total acquisition cost since December 2011
Patriot Advanced Capability-3 Missile Segment Enhancement (PAC-3 MSE)	6,882.40	8,062.34	-14.6	3.2	-22.7
Space Based Infrared System High (SBIRS High)	3,464.31	3,930.24	-11.9	3.5	-11.9
Small Diameter Bomb Increment II (SDB II)	4,390.29	5,202.30	-15.6	0.2	5.7
Standard Missile-6 (SM-6)	9,674.83	6,306.77	53.4	3.2	45.9
Space Fence Ground-Based Radar System Increment 1	1,570.17	1,664.72	-5.7	-0.9	-5.7
Ship to Shore Connector Amphibious Craft (SSC)	4,622.51	4,373.93	5.7	13.3	5.7
SSN 774 Virginia Class Submarine (SSN 774)	137,099.81	66,881.28	105.0	40.6	50.4
Tactical Tomahawk RGM-109E/UGM 109E Missile (TACTOM)	7,518.01	2,341.40	221.1	5.5	-5.5
Trident II (D-5) Sea-Launched Ballistic Missile UGM 133A (Trident II Missile)	59,636.42	52,233.71	14.2	-0.1	1.6
UH-60M Black Hawk Helicopter (UH-60M Black Hawk)	28,012.86	14,351.28	95.2	3.7	-2.8
V-22 Osprey Joint Services Advanced Vertical Lift Aircraft (V-22)	65,076.53	44,371.15	46.7	0.4	3.3
VH-92A Presidential Helicopter Replacement Program	4,859.34	4,939.13	-1.6	-1.1	-1.6
Wideband Global SATCOM (WGS)	4,177.63	1,320.83	216.3	-4.1	-5.6
Warfighter Information Network-Tactical Increment 2 (WIN-T Inc 2)	11,203.43	4,102.63	173.1	2.8	66.9
Warfighter Information Network-Tactical Increment 3 (WIN-T Inc 3)	2,077.79	18,109.63	-88.5	-0.1	-84.9

Source: GAO analysis of DOD data. | GAO-18-360SP

Note: We obtained data for this table from DOD’s Selected Acquisition Reports.

Appendix V: Cost and Schedule Changes over 5 Years and since First Full Estimates for the 86 Programs in DOD's 2017 Portfolio

Table 14 shows the 2017 portfolio's aggregate changes in research and development, procurement, and total acquisition costs, as well as average delays in delivering operational capability, over the last 5 years and since programs' first full estimates.

Table 14: Cost and Schedule Changes for Programs in DOD's 2017 Portfolio

Fiscal year 2018 dollars

	5-year comparison (December 2011 to December 2016)	Since first full estimate (baseline to December 2016)
Change in total research and development cost	$19.8 billion 6.7 percent	$103.1 billion 48.9 percent
Change in total procurement cost	52.7 billion 4.1 percent	430.8 billion 47.9 percent
Change in total other acquisition costs[a]	-0.9 billion -6.1 percent	2.9 billion 26 percent
Change in total acquisition cost	73.0 billion 4.6 percent	536.8 billion 47.9 percent
Average delay in delivering initial capabilities	10.9 months 13.7 percent	27.4 months 37.7 percent

Source: GAO analysis of DOD data | GAO-18-360SP

Note: We obtained table data from DOD's Selected Acquisition Reports. Some numbers may not sum due to rounding.

[a]Other total acquisition costs include acquisition-related operation and maintenance and system-specific military construction costs.

Appendix VI: Technology Readiness Levels

Table 15: Technology Readiness Levels and Descriptions

Technology readiness level	Description	Hardware/software	Demonstration environment
1. Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Examples might include paper studies of a technology's basic properties.	None (paper studies and analysis)	None
2. Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. The application is speculative and there is no proof or detailed analysis to support the assumption. Examples are still limited to paper studies.	None (paper studies and analysis)	None
3. Analytical and experimental critical function and/or characteristic proof of concept	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.	Analytical studies and demonstration of non-scale individual components (pieces of subsystem)	Lab
4. Component and/or breadboard validation in laboratory environment	Basic technological components are integrated to establish that the pieces will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of "ad hoc" hardware in a laboratory.	Low-fidelity breadboard. Integration of nonscale components to show pieces will work together. Not fully functional or form or fit but representative of technically feasible approach suitable for flight articles.	Lab
5. Component and/or breadboard validation in relevant environment	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so that the technology can be tested in a simulated environment. Examples include "high fidelity" laboratory integration of components.	High-fidelity breadboard. Functionally equivalent but not necessarily form and/or fit (size weight, materials, etc). Should be approaching appropriate scale. May include integration of several components with reasonably realistic support elements/subsystems to demonstrate functionality.	Lab demonstrating functionality but not form and fit. May include flight demonstrating breadboard in surrogate aircraft. Technology ready for detailed design studies.

Technology readiness level		Description	Hardware/software	Demonstration environment
6.	System/subsystem model or prototype demonstration in a relevant environment	Representative model or prototype system, which is well beyond the breadboard tested for TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high fidelity laboratory environment or in simulated realistic environment.	Prototype. Should be very close to form, fit and function. Probably includes the integration of many new components and realistic supporting elements/subsystems if needed to demonstrate full functionality of the subsystem.	High-fidelity lab demonstration or limited/restricted flight demonstration for a relevant environment. Integration of technology is well defined.
7.	System prototype demonstration in an operational environment	Prototype near or at planned operational system. Represents a major step up from TRL 6, requiring the demonstration of an actual system prototype in a realistic environment, such as in an aircraft, vehicle, or space. Examples include testing the prototype in a test bed aircraft.	Prototype. Should be form, fit and function integrated with other key supporting elements/subsystems to demonstrate full functionality of subsystem.	Flight demonstration in representative realistic environment such as flying test bed or demonstrator aircraft. Technology is well substantiated with test data.
8.	Actual system completed and “flight qualified” through test and demonstration	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.	Flight-qualified hardware	Developmental Test and Evaluation in the actual system application.
9.	Actual system “flight proven” through successful mission operations	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. In almost all cases, this is the end of the last “bug fixing” aspects of true system development. Examples include using the system under operational mission conditions.	Actual system in final form	Operational Test and Evaluation in operational mission conditions.

Source: GAO and its analysis of National Aeronautics and Space Administration data. | GAO-18-360SP

Appendix VII: Comments from the Department of Defense

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ACQUISITION AND SUSTAINMENT

Ms. Shelby S. Oakley
Director, Acquisition and Sourcing Management
U.S. Government Accountability Office
441 G St NW
Washington, DC 20548

APR 09 2018

Dear Ms. Oakley,

This is the Department of Defense (DoD) response to the Government Accountability Office (GAO) Draft Report, GAO-18-360SP, "Defense Weapon Systems: Programs Initiated after Acquisition Reforms Show Improved Performance, but Knowledge Shortfalls Persist" dated April 3, 2018 (GAO Code 102042).

The Department is pleased GAO findings show measurable improvements to the DoD Acquisition System as a result of major reform initiatives started in 2010 and continuing in the current Administration. The Department remains committed to driving down the costs of our weapon systems and reducing the time it takes to deliver them to our Warfighters. The separation of the Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics into the Office of the Under Secretary of Defense for Acquisition and Sustainment and the Office of the Under Secretary of Defense for Research and Engineering presents the next major shift in how the Department develops and procures weapon systems.

This report documents that the Department continues to show improved cost performance while expanding the total acquisition portfolio size and cost. That is an encouraging finding as the Department makes a strategic turn to increase investment in our technology edge over our adversaries.

The Department appreciates the opportunity to comment on the Draft Report. My point of contact for this effort is LCDR Jake Ferrari at 703-697-8020.

Sincerely,

Nancy L. Spruill

Nancy L. Spruill
Director
Acquisition Resources and Analysis

Appendix VIII: GAO Contact and Staff Acknowledgments

GAO Contact

Shelby S. Oakley, (202) 512-4841 or oakleys@gao.gov

Staff Acknowledgments

Principal contributors to this report were Christopher R. Durbin, Assistant Director; Marcus Ferguson, Program Assessments Analyst-in-Charge; J. Andrew Walker, Portfolio Analysis Analyst-in-Charge; Adrienne Austin; Jenna Blair; Emily Bond; Tana M. Davis; Wendy P. Smythe; and Robin M. Wilson. Other key contributors included Matthew Ambrose, Cheryl K. Andrew, Andrew H. Berglund, David B. Best, Matthew Crosby, Mary C. Diop, Jeffrey L. Hartnett, Leigh Ann Haydon, Rich Horiuchi, Wendell K. Hudson, Justin M. Jaynes, J. Kristopher Keener, Jill N. Lacey, Katherine Lenane, Travis J. Masters, LaTonya D. Miller, Diana Moldafsky, Anh Nguyen, Anna Maria Ortiz, Scott M. Purdy, Beth Reed Fritts, Carrie Rogers, Ronald E. Schwenn, Charlie Shivers III, Jay Tallon, Brian A. Tittle, Bruce H. Thomas, Nathan A. Tranquilli, Nathaniel Vaught, Abby C. Volk, Alyssa B. Weir, Khristi A. Wilkins, and Tonya Woodbury.

Table 16 lists the staff responsible for individual program assessments.

Table 16: GAO Staff Responsible for Individual Program Assessments

Program name	Primary staff
Army programs	
Airborne & Maritime/Fixed Station (AMF)	Tana M. Davis, Jenna Blair
Armored Multi-Purpose Vehicle (AMPV)	Charlie Shivers III, Eli DeVan
Common Infrared Countermeasure (CIRCM)	Jacqueline W. Wade, Carol Mebane
Handheld, Manpack, and Small Form Fit Radios (HMS)	Scott M. Purdy, Jessica E. Karnis
Improved Turbine Engine Program (ITEP)	Wendy P. Smythe, Jenna Blair
Indirect Fire Protection Capability Increment 2 – Intercept, Block 1 (IFPC Inc 2-I Block 1)	Brian T. Smith, Zachary Sivo
Integrated Air and Missile Defense (IAMD)	Julie C. Hadley, Erin L. Stockdale
Joint Air-to-Ground Missile (JAGM)	Jessica M. Berkholtz, Jenny Shinn
Long Range Precision Fires (LRPF)	Cale Jones, Billy Allbritton
M109A7 Family of Vehicles (M109A7 FOV)	Billy Allbritton, Cale Jones
Patriot Advanced Capability-3 Missile Segment Enhancement (PAC-3 MSE)	Zachary Sivo, Tana M. Davis
Navy and Marine Corps programs	
Air and Missile Defense Radar (AMDR)	Nathan Foster, Sean D. Merrill
Amphibious Combat Vehicle (ACV 1.1)	Matthew M. Shaffer, Alexandra Jeszeck
Amphibious Ship Replacement (LX(R))	Samuel Woo, Holly Williams

Program name	Primary staff
CH-53K Heavy Lift Replacement Helicopter (CH-53K)	Victoria C. Klepacz, Lauren Wright
CVN 78 Gerald R. Ford Class Nuclear Aircraft Carrier (CVN 78)	Burns C. Eckert, Lindsey Cross
DDG 51 Arleigh Burke Class Destroyer, Flight III (DDG 51 Flight III)	Jillian C. Schofield, Laura M. Jezewski
DDG 1000 Zumwalt Class Destroyer (DDG 1000)	Ramzi N. Nemo, Angie Nichols-Friedman , Luqman M. Abdullah
Guided Missile Frigate FFG(X) (Guided Missile Frigate)	Sean D. Merrill, Jeff Hartnett
Ground/Air Task Oriented Radar (G/ATOR)	Joe E. Hunter, Claire Li
John Lewis Class Fleet Replenishment Oiler (T-AO 205)	Matthew Ambrose, Jocelyn C. Yin, Daniel M. Kuhn
Joint Precision Approach and Landing System (JPALS)	Stephen V. Marchesani, Jennifer A. Dougherty
LHA 6 America Class Amphibious Assault Ship (LHA 6)	Jeffrey L. Hartnett, Dennis A. Antonio
Littoral Combat Ship (LCS)	Elisha T. Matvay, Jacob L. Beier, Brendan K. Orino
Littoral Combat Ship - Mission Modules (LCS Packages)	Laurier R. Fish, Tonya Woodbury, Ruben G. Gzirian
MQ-4C Triton Unmanned Aircraft System (MQ-4C Triton)	Erin L. Stockdale, Tonya Woodbury
MQ-8 Fire Scout (MQ-8 Fire Scout)	James Kim, Raffaele Roffo
MQ-25 Unmanned Aircraft System (MQ-25 Stingray)	Jillena Roberts, Robert Bullock
Next Generation Jammer Mid-Band (NGJ Mid-Band)	Carmen Yeung, Laura T. Holliday
Offensive Anti-Surface Warfare Increment 1 (OASuW Inc 1)	Thomas P. Twambly, Leslie C. Ashton, Sean T. Sannwaldt
P8-A Poseidon Multi-Mission Maritime Aircraft Increment 3 (P-8A Inc. 3)	Heather B. Miller, Jocelyn C. Yin
Ship to Shore Connector Amphibious Craft (SSC)	Teague A. Lyons, Gina M. Flacco
SSBN 826 Columbia Class Ballistic Missile Submarine (SSBN 826)	Lindsey Cross, James Madar
SSN 774 Virginia Class Submarine Block V (SSN 774 Block V)	Jenny Shinn, James Madar
VH-92A Presidential Helicopter Replacement Program (VH-92A)	Bonita J. P. Oden, Ramzi N. Nemo
Air Force programs	
Advanced Pilot Training (APT)	Marvin Bonner, Meghan Perez
B-2 Defensive Management System Modernization (B-2 DMS-M)	Matthew B. Lea, Megan Setser
B-2 Extremely High Frequency Satellite Communications (B-2 EHF SATCOM)	Matthew Metz, Mary C. Diop
Combat Rescue Helicopter (CRH)	Sean C. Seales, Matthew T. Drerup
Evolved Expendable Launch Vehicle (EELV)	Erin R. Cohen, Laura D. Hook
F-15 Eagle Passive Active Warning Survivability System (F-15 EPAWSS)	Matthew T. Drerup, LeAnna M. Parkey
F-22 Increment 3.2B Modernization (F-22 Inc 3.2B Mod)	Nathaniel Vaught, Sean C. Seales
Family of Advanced Beyond Line-of-Sight Terminals Command Post Terminals (FAB-T CPT)	Alexandra Dew Silva, Andrew H. Berglund
Global Positioning System III (GPS III)	Jonathan Mulcare, Erin R. Cohen, William V. Lamping
Global Positioning Satellite Next Generation Operational Control System (GPS OCX)	Patrick Breiding, Claire Buck, Alexandra D. Gebhard

Program name	Primary staff
Ground Based Strategic Deterrence (GBSD)	Maricela Cherveny, Meredith Allen Kimmett
KC-46A Tanker Modernization Program (KC-46A)	Katheryn S. Hubbell, Nathaniel Vaught, Adrienne Austin
Joint Surveillance Target Attack Radar System Recapitalization (JSTARS Recap)	Sameena Ismailjee, J. Andrew Walker
Military Global Positioning Satellite User Equipment Increment 1 (MGUE Increment 1)	Erin E. Carson, Claire Buck
Small Diameter Bomb Increment II (SDB II)	Suzanne Sterling, John W. Crawford
Space Fence Ground Based Radar System Increment 1 (Space Fence Inc 1)	Laura D. Hook, Mary C. Diop
Three-Dimensional Expeditionary Long-Range Radar (3DELRR)	Claire Li, Joe E. Hunter, Colleen Taylor
Utility Helicopter Replacement (UH-1N) Replacement	Jonathan Munetz, Cody Knudsen
VC-25B Presidential Aircraft Recapitalization (VC-25B PAR)	LeAnna M. Parkey, Katherine M. Pfeiffer
Weather System Follow-on - Microwave (WSF-M)	Brenna Derritt, Maricela Cherveny
Joint Department of Defense programs	
F-35 Lightning II Joint Strike Fighter Program (F-35)	Desiree E. Cunningham, Jennifer K. Leone
Joint Light Tactical Vehicle (JLTV)	Marcus C. Ferguson, Andrea C. Evans

Source: GAO. | GAO-18-360SP

Related GAO Products

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