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WEAPON SYSTEMS ANNUAL ASSESSMENT

Limited Use of Knowledge-Based Practices Continues to Undercut DOD's Investments

Accessible Version

GAO-19-336SP

WEAPON SYSTEMS ANNUAL ASSESSMENT

Limited Use of Knowledge-Based Practices Continues to Undercut DOD's Investments

Highlights

Highlights of GAO-19-336SP.

This year's assessment comes at a time of significant change to how DOD manages and oversees its major weapons programs. At the direction of Congress, DOD restructured the Office of the Secretary of Defense to focus more on capability development and less on program oversight, which now resides primarily with the three military departments. Amid these changes, this year GAO found that cost performance has slipped. Further, unlike prior years, programs initiated after major acquisition reforms were implemented in 2010 are now showing cost growth.

This report provides observations on:

1. cost and schedule performance and contract awards for DOD's 2018 portfolio of 82 programs that provide acquisition reports to Congress and
2. knowledge that 51 selected programs attained at key points in the acquisition process.

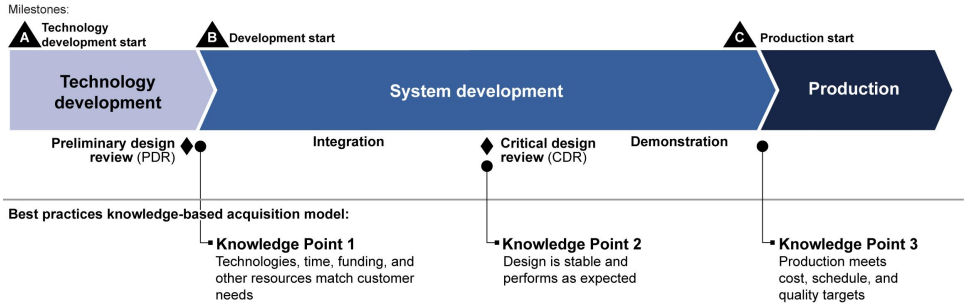
Further, GAO presents individual assessments of 51 programs.

View GAO-19-336SP. For more information, contact Shelby S. Oakley at (202) 512-4841 or oakleys@gao.gov.

This special report is GAO's 17th annual assessment of the Department of Defense's (DOD) $1.69 trillion portfolio of 82 major weapon systems acquisition programs. This report (1) examines changes in the portfolio since last year, (2) evaluates DOD's actions in areas related to recent, selected acquisition reforms, and (3) offers a quick look at cost and schedule performance of 51 individual weapon programs based on DOD documentation and questionnaire responses from their respective program offices.

For years, GAO has highlighted the importance of applying knowledge-based acquisition practices as a way to improve DOD's program outcomes. When programs enter development with insufficient knowledge, negative effects often cascade throughout the acquisition cycle. The figure below shows how three acquisition phases—technology development, system development, and production—align with three key points for demonstrating knowledge.

Department of Defense (DOD) Acquisition Process

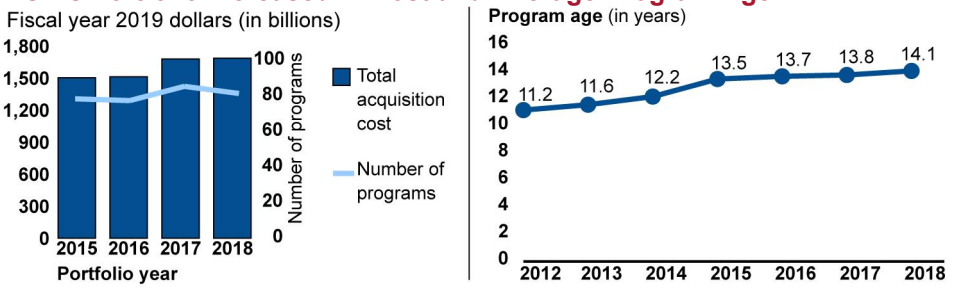


Source: GAO analysis of DOD-provided data, DOD Instruction 5000.02, and best practices. | GAO-19-336SP

DOD's 2018 Portfolio Is Smaller, yet Older and More Expensive than Last Year; Contracting Has Often Been Characterized by Ineffective Competition

DOD's 2018 portfolio of major weapon programs has grown in cost by $8 billion, but contains four fewer systems than last year. GAO's analysis suggests that one of the primary drivers of this cost growth is that, since 2012, the average age of programs has increased—indicative of DOD decisions to introduce new capabilities through additions to existing programs rather than by starting new programs. On average, programs in the current portfolio are about 4 months older than last year and nearly 3 years older than in 2012. (See figure.)

DOD's Portfolio Increased in Cost and Average Program Age

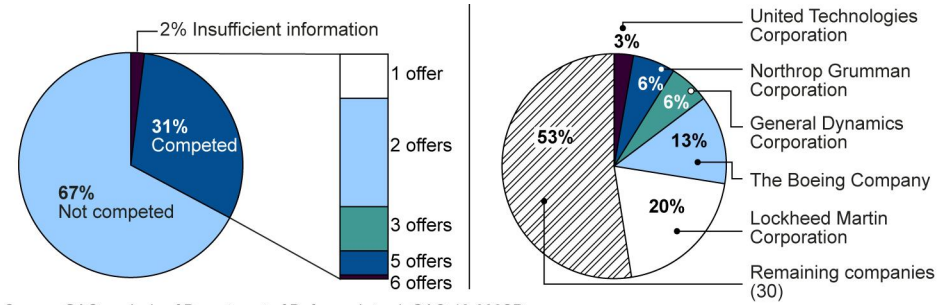


Source: GAO analysis of Department of Defense data. | GAO-19-336SP

Portfolio-wide cost growth has occurred in an environment where awards are often made without full and open competition. Specifically, GAO found that DOD

did not compete 67 percent of 183 major contracts currently reported for its 82 major programs. GAO also observed that DOD awarded 47 percent of these 183 contracts to five corporations and entities connected with them. (See figure.)

DOD Programs Competed One-Third of Currently Reported Major Contracts with Nearly Half of Awards Concentrated within Five Companies



Source: GAO analysis of Department of Defense data. | GAO-19-336SP

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

As we have reported in previous assessments, DOD programs continue not to fully implement knowledge-based acquisition practices. GAO observed that most of the 45 current programs proceeded into system development, through critical design reviews, and into production without completing the key knowledge-based practices associated with each of these three points. (See table.)

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

Practices associated with the three key knowledge points (KP)	Programs that completed the KP before this assessment period	Programs that completed the KP during this assessment period
KP 1 practices	**38 programs**	**Four programs**
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	50 - 74 percent	50 - 74 percent
Demonstrate all critical technologies are in form, fit, and, function within a realistic environment	0 - 49 percent	0 - 49 percent
Completed preliminary design review before system development start	50 - 74 percent	0 - 49 percent

Practices associated with the three key knowledge points (KP)	Programs that completed the KP before this assessment period	Programs that completed the KP during this assessment period
KP 2 practices	**33 programs**	**Two programs**
Release at least 90 percent of design drawings to manufacturing	0 - 49 percent	75 - 100 percent
Test a system-level integrated prototype	0 - 49 percent	0 - 49 percent

Practices associated with the three key knowledge points (KP)	Programs that completed the KP before this assessment period	Programs that completed the KP during this assessment period
KP 3 practices	**15 programs**	**Three programs**

Practices associated with the three key knowledge points (KP)	Programs that completed the KP before this assessment period	Programs that completed the KP during this assessment period
KP 3 practices	**15 programs**	**Three programs**
Demonstrate critical manufacturing processes are in statistical control	0 - 49 percent	0 - 49 percent
Demonstrate critical processes on a pilot production line	50 - 74 percent	75 - 100 percent
Test a production-representative prototype in its intended environment	0 - 49 percent	75 - 100 percent

Programs completing each best practice: ● 75 - 100 percent; ◐ 50 - 74 percent; ◯ 0 - 49 percent

Source: GAO analysis of Department of Defense data. | GAO-19-336SP

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. In 2018, GAO conducted an exploratory statistical analysis of 15 programs in production to evaluate their completion of the eight key knowledge-based acquisition practices. In 2019, GAO expanded this analysis to include 17 programs. Over the past two years, GAO found that the major DOD acquisition programs that completed one or more of three specific practices 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.

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Abbreviations

AEHF	Advanced Extremely High Frequency Satellite
CDR	Critical Design Review
CPAF	cost-plus-award-fee
CPFF	cost-plus-fixed-fee
CPIF	cost-plus-incentive fee
CVN 78	Gerald R. Ford Class Nuclear Aircraft Carrier

DAMIR	Defense Acquisition Management Information Retrieval
DDG 51	DDG 51 Arleigh Burke Class Guided Missile Destroyer
DOD	Department of Defense
eSRS	Electronic Subcontracting Reporting System
F-35	F-35 Lightning II Joint Strike Fighter
FFP	firm-fixed-price
FPDS-NG	Federal Procurement Data System-Next Generation
FPI	fixed-price incentive
IDIQ	indefinite-delivery/indefinite-quantity
MDAP	Major Defense Acquisition Program
MH-60R	MH-60R Multi-Mission Helicopter
MRL	manufacturing readiness level
NA	not applicable
NDAA	National Defense Authorization Act
OMB	Office of Management and Budget
P-8A Increment 3	P-8A Poseidon, Increment 3
SAR	Selected Acquisition Report
SBIRS High	Space Based Infrared System High
SSN 774	SSN 774 Virginia Class Submarine
TBD	to be determined
TRL	technology readiness level
USAF	United States Air Force
USMC	United States Marine Corps
USN	United States Navy
WIN-T Inc. 2	Warfighter Information Network-Tactical Increment 2
WIN-T Inc. 3	Warfighter Information Network-Tactical Increment 3
WSARA	Weapon Systems Acquisition Reform Act

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U.S. GOVERNMENT ACCOUNTABILITY OFFICE

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Comptroller General
of the United States

May 7, 2019

Congressional Committees

I am pleased to present our 17th annual assessment of the Department of Defense's (DOD) major weapon system acquisition programs—an area on GAO's high-risk list since 1990.[1] This year's report offers observations on the performance of DOD's 2018 portfolio of 82 major programs, which the department expects to cost $1.69 trillion in total.[2] This significant financial investment demands keen oversight and continued implementation of legislative reforms and policies aimed at improving DOD's stewardship. These include use of knowledge-based acquisition practices, which we have previously recommended to DOD, but which continue to lack consistent application within the department.

This year's assessment comes at a time of significant change within the department. In response to congressional direction, in February 2018, DOD dissolved the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics. DOD has developed a new organizational structure that refocuses the Office of the Secretary of Defense's (OSD) principal acquisition function to one focused on increasing the speed of capability development rather than conducting program oversight. As part of this restructure, overall responsibilities for program oversight, which DOD calls "milestone decision authority," now generally reside within the three military departments.

We recognize the magnitude of these changes and, through our ongoing work, know that OSD and the military departments have made some progress implementing them. At the same time, we observed this year that cost performance in major programs continues to slip. Most troubling

[1]GAO, *High-Risk Series: Substantial Efforts Needed to Achieve Greater Progress on High-Risk Areas*, GAO-19-157SP (Washington, D.C.: Mar. 6, 2019).

[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. Although 10 U.S.C. § 225 requires the Missile Defense Agency (MDA) to establish and maintain an acquisition baseline for certain elements of the BMDS, these baselines are not the same as the acquisition program baselines developed pursuant to 10 U.S.C. § 2435 and DOD acquisition policies, and they do not provide all the data we need to assess cost and schedule changes. For more information on BMDS and its elements, see GAO, *Missile Defense: The Warfighter and Decision Makers Would Benefit from Better Communication about the System's Capabilities and Limitations*, GAO-18-324 (Washington, D.C.: May 30, 2018).

is that DOD's newer programs—those initiated after implementation of major acquisition reforms in 2010—now show aggregate cost growth. In previous assessments, we observed that this group of programs generated cost decreases that, in part, offset cost increases within the rest of the portfolio.

We attribute the deteriorating performance of newer programs to the inconsistent implementation of knowledge-based acquisition practices—a condition we highlighted in our 2018 assessment. 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 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. While DOD has often agreed with these recommendations, and incorporated them into its acquisition policy, it has inconsistently applied the policy to its acquisition programs.

Further, for the second year in a row, we completed an exploratory statistical analysis that continues to validate a linkage between the attainment of knowledge and the real-life cost and schedule outcomes that programs deliver. This year we expanded our data set by two programs to a total of 17, each of which has entered production. Over the past two years, our analyses show that, consistent with our best practices, programs that attained certain knowledge at key points had lower cost and schedule growth than other programs.

As evidence of the importance of knowledge-based acquisition practices continues to mount, we are troubled by DOD's continued reluctance to fully adopt them. Service acquisition executives, now assigned as the milestone decision authority for most major programs within their military departments, are positioned to insist that programs under their purview implement knowledge-based practices. Such leadership, if displayed, could help reverse the cost growth we observed and position the military departments to obtain persistent efficiencies in the acquisition programs they manage.

Gene L. Dodaro
Comptroller General of the United States

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May 7, 2019

Congressional Committees

In response to the joint explanatory statement accompanying the Department of Defense Appropriations Act, 2009, this report provides insight into the department's $1.69 trillion portfolio of major weapon programs.[1] It includes observations on (1) the cost and schedule performance of DOD's 2018 portfolio of 82 major weapon programs, (2) the extent to which 51 current and future programs (i.e., those that have not yet begun development) are implementing recent key acquisition reform initiatives, and (3) the knowledge attained by 51 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 (NDAA) 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:

[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.

- We assessed 82 major defense acquisition programs (MDAP) in DOD's 2018 portfolio for cost and schedule performance and their use of competition in contracting.[4]
    - First, we obtained cost, schedule, and quantity data from DOD's December 2017 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 assessed 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.
    - Next, we identified active major development and procurement contracts that programs reported in their December 2017 SARs and entered those contract numbers into the Federal Procurement Data System—Next Generation (FPDS-NG) to obtain data specific to those contracts.[5] We assessed data reliability by obtaining and reviewing a federal-wide summary of the system's completeness and accuracy and the data validation rules and determined that 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 program officials 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 program officials provide

[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 MDAPs. 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 pre-MDAPs throughout this report. Recent amendments to the statutory definition of an MDAP expressly exclude those acquisitions using the rapid fielding or rapid prototyping acquisition pathway described in section 804 of the National Defense Authorization Act for Fiscal Year 2016.

[5] FPDS-NG is an automated system used to collect and report on federal procurement spending and the authoritative source for government-wide contract award data.

details on scheduling, critical technology levels, major development and early procurement contract data, and other information. We received questionnaire responses from all 45 current MDAPs from October 2018 through January 2019.

- We also assessed six 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 recent key acquisition reforms. We provided a questionnaire to program offices to obtain information on schedule events, costs, and acquisition reforms, and received responses from all six future programs from October 2018 through December 2018.

In addition, we present individual assessments of 51 MDAPs, which include the 45 MDAPs currently in development or early production, as well as the six future programs. We used December 2017 SAR data as a starting point for reporting program cost information in the individual assessments. For most assessments, we were able to include more current cost information that we obtained through our web-based questionnaires. Appendix II provides additional information on our objectives, scope, and methodology.

We conducted this performance audit from May 2018 to May 2019 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.[6] This system includes three phases that defense acquisition programs generally proceed through, which are (1) technology maturation and risk reduction, (2) engineering and manufacturing development, and (3) production and

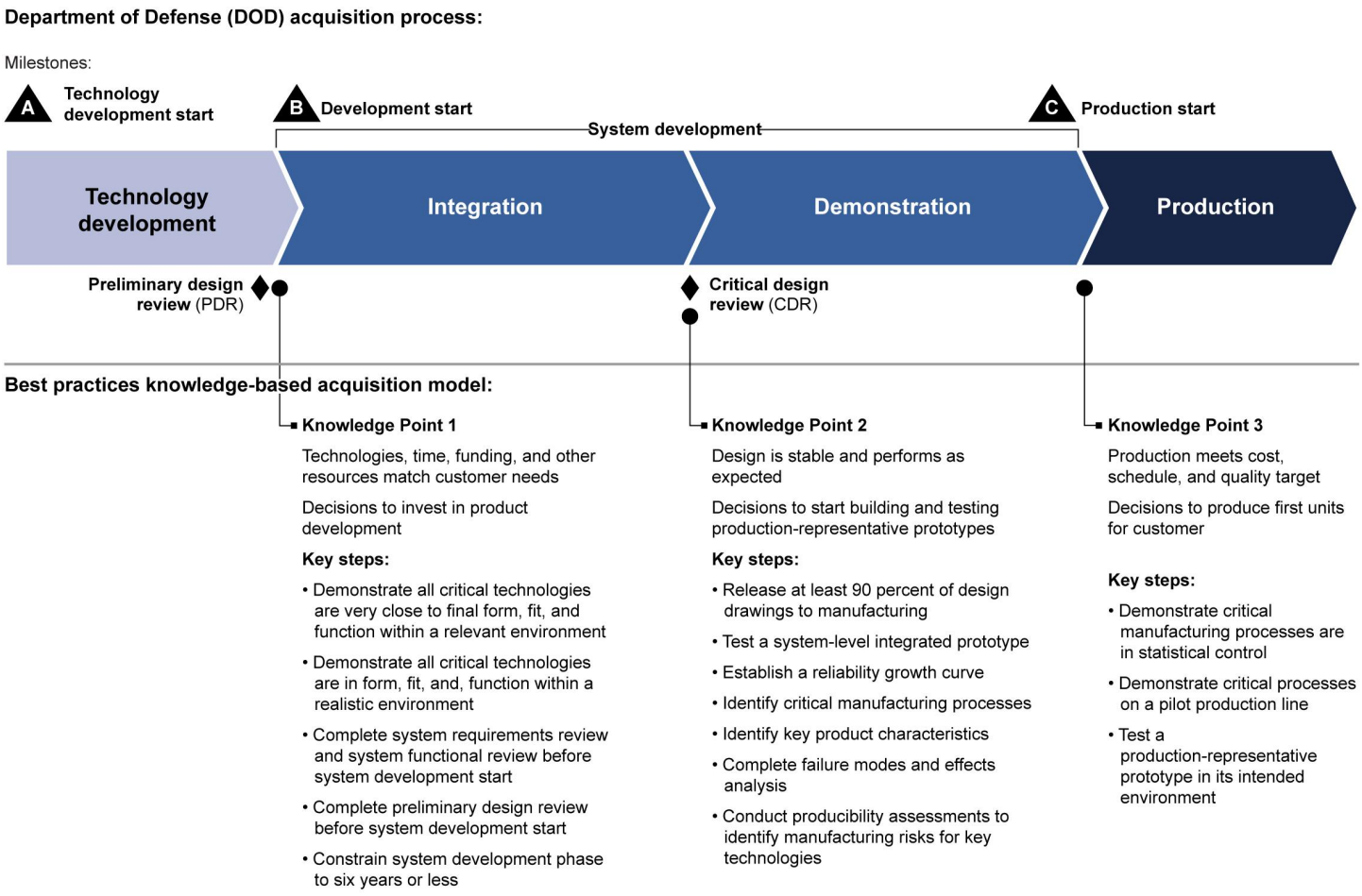
[6]Department of Defense Directive 5000.01, The Defense Acquisition System (May 2003 [incorporating change 2 (Aug. 2018)]); Department of Defense Instruction 5000.02, Operation of the Defense Acquisition System (Jan. 2015) [incorporating change 4 (Aug. 2018)] ("DOD Instruction 5000.02").

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 programs make significant commitments during product development drives positive acquisition outcomes.[7] 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.

[7] 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: DOD Acquisition Process and GAO-identified Knowledge Points



Source: GAO analysis of DOD-provided data, DOD Instruction 5000.02, and best practices. | GAO-19-336SP

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 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. To accommodate shipbuilding

programs in this report, we correlated detail design contract awards, fabrication starts, and lead ship deliveries with development start, critical design review, and production start, respectively.

Our work has led to multiple recommendations that DOD has generally or partially agreed with and took steps to implement some of them in its acquisition policy. 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.[8] 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.

More recently, the Congress has passed legislation that introduced numerous additional acquisition reforms related to improving the performance of weapon acquisition programs. For this assessment, we reviewed MDAP implementation of several of these reforms. We focused on the reforms that involve oversight and acquisition principles consistent with our knowledge-based practices and provide mechanisms for more rapid fielding of warfighter capability. We explain the reforms in greater detail in appendix IV. These acquisition reforms are summarized as follows:

- The **NDAA for fiscal year 2016** contained specific provisions that authorize changes in certain areas of DOD's acquisition process.[9] For example, some of these provisions included language pertaining to the alternate pathways for rapidly prototyping and fielding new capabilities, waivers of certain acquisition-related laws, and revisions to milestone decision responsibilities for MDAPs. The NDAA for fiscal year 2016 also contained a provision that permanently codified DOD's "other transaction" authority for prototype projects. Under this

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

[9]Pub. L. No. 114-92.

authority, programs can enter into what are commonly referred to as "other transaction agreements," which generally are not subject to federal acquisition or assistance statutes and regulations. Consequently, this authority provides agencies more flexibility to meet project requirements and mission needs.

- The **NDAA for fiscal year 2017** included provisions that require new acquisition programs to be designed and developed, to the maximum extent practicable, with a modular, open systems approach to enable incremental development and enhance competition, innovation, and interoperability.[10] It also included provisions that require an independent technical risk assessment in certain instances and goals for procurement unit cost, sustainment costs, initial operational capability, technology maturation, and prototyping.
- The **NDAA for fiscal year 2018** contained a provision titled "expanded other transaction authority for prototype projects" that increased the dollar values of the DOD-internal approval thresholds.

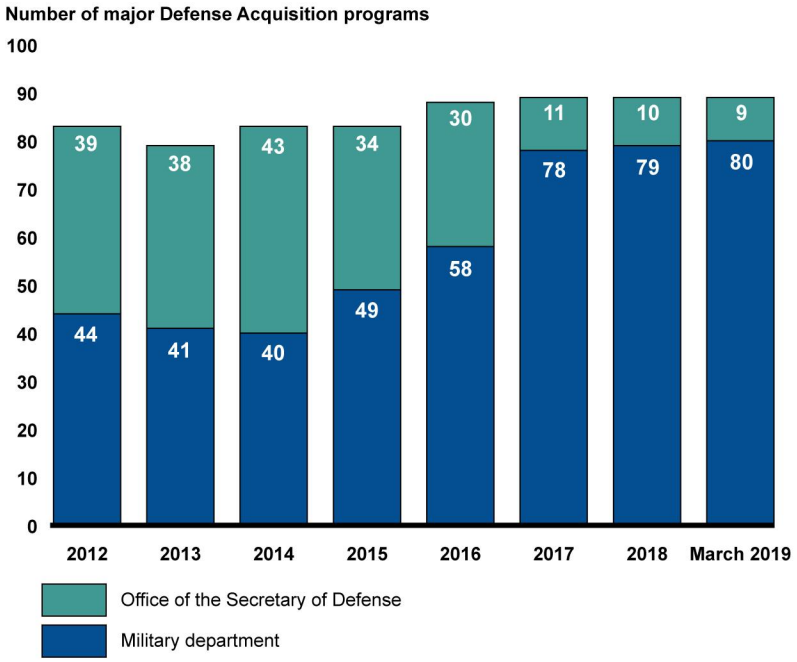
The 2016 and 2017 NDAAs also contained provisions that altered the roles and responsibilities for MDAP oversight to give significantly more authority to the military departments for managing acquisition programs. Among other things, these provisions required the following:

- The service acquisition executive of the military department concerned be designated as the milestone decision authority for most MDAPs initiated after October 1, 2016;
- A process to address requests from service acquisition executives to revert existing programs' milestone decision authority to them;
- The establishment of two new executive offices—the Offices of the Under Secretary of Defense for Research and Engineering and the Under Secretary of Defense for Acquisition and Sustainment, which replaced the Under Secretary of Defense for Acquisition, Technology and Logistics; and
- Use of an alternate milestone decision authority, under certain circumstances.

The movement of milestone decision authority has begun to take place, as shown in figure 2.

[10]Pub. L. No. 114-328.

Figure 2: Milestone Decision Authority in DOD's Portfolio of Major Defense Acquisition Programs, 2012-2019



Source: GAO analysis of Department of Defense data. | GAO-19-336SP

Note: The figure does not account for classified programs, which we excluded from our analyses.

We have ongoing work to more comprehensively assess DOD's implementation of these and other recent acquisition reforms and we expect to issue a report in spring 2019. As part of that review, we are evaluating DOD's new organizational structure that refocuses the Office of the Secretary of Defense's principal role from program oversight to one intended to ensure that major DOD investments produce integrated, technically superior capability that consistently outpaces global threats.

Nine Observations on the Performance of DOD's 2018 MDAP Portfolio

DOD's 2018 MDAP portfolio consists of 82 programs and will cost $1.69 trillion to acquire.[11] We identified MDAPs as being in the 2018 portfolio if they published a December 2017 SAR. The portfolio is smaller yet more

[11]All dollar figures are in fiscal year 2019 constant dollars, unless otherwise noted.

expensive than last year's portfolio. The estimated total acquisition cost of the portfolio has grown by 51 percent, or $569 billion, since the identified programs' first full estimates. While programs initiated since 2010 continue to outperform those initiated earlier, our analysis of the current portfolio indicates that this trend has weakened. The result is portfolio-wide cost growth and a loss of buying power gains. Moreover, this growth has occurred in an acquisition environment where DOD has awarded 86 of the 183 major contracts that we reviewed to five corporations or entities connected with them and where most of the major contracts as reported in the SARs were awarded without full and open competition or on a sole source basis. In addition, current MDAPs did not compete 123 of these 183 contracts.

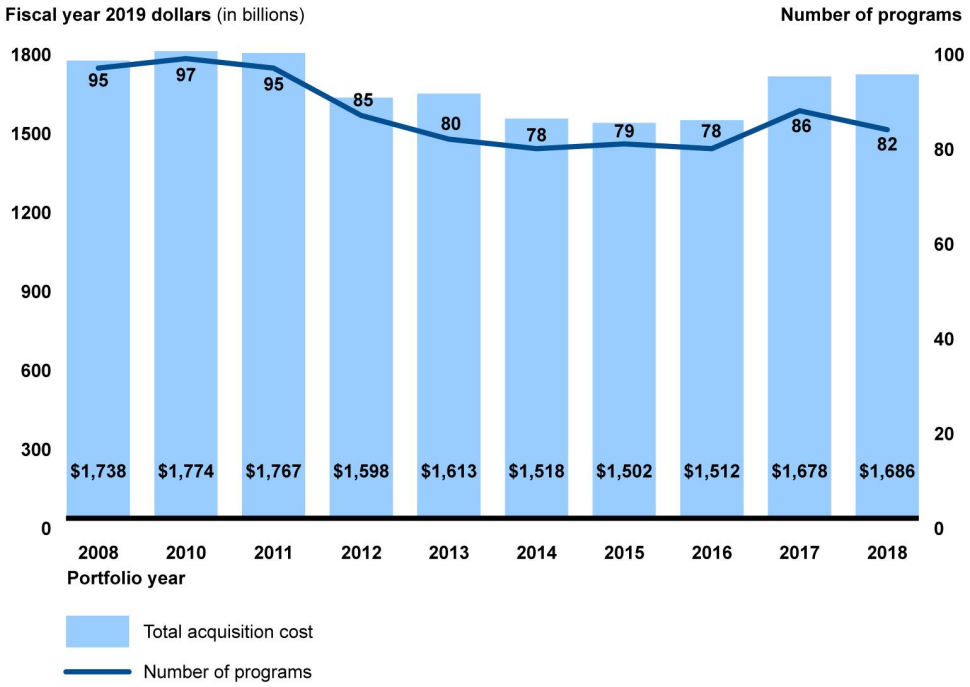
DOD's 2018 Portfolio Invested More Money across Fewer Programs

Observation 1. The 2018 portfolio consists of 82 programs that will cost $1.69 trillion to acquire. This portfolio has four fewer programs than last year's portfolio, but will require more money than any portfolio from the prior six years.

- The current portfolio is smaller yet more expensive that last year's portfolio. This is the third time in 10 years that a decrease in the number of portfolio systems was not accompanied by a corresponding decrease in expected costs. Specifically, the 2018 portfolio is 14 percent smaller than the 2008 portfolio, yet its projected completion cost is only 3 percent less since that time.
- The average total acquisition cost per program has continued to increase over the last decade. In 2008, the average cost of an acquisition program was $18.3 billion, while the comparative average cost for 2018 is $20.6 billion.

Figure 3 shows the number of programs and the total cost of the 2018 portfolio in relation to previous years.

Figure 3: Historical DOD Portfolio Comparison



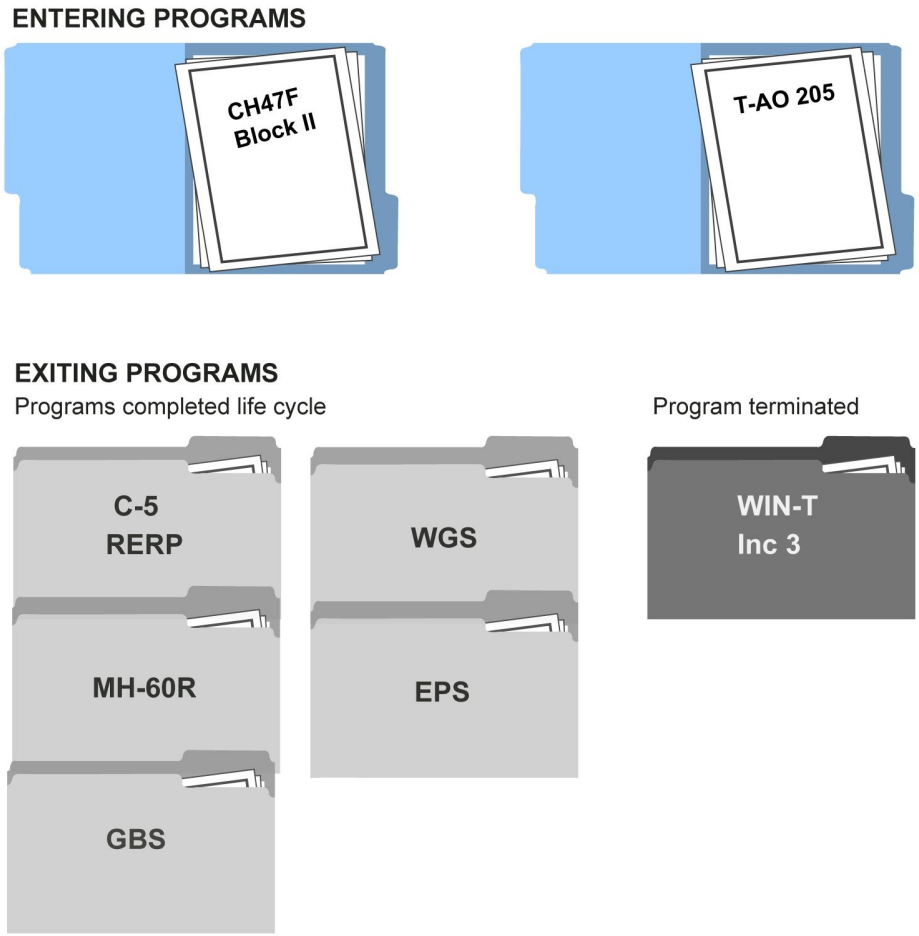
Source: GAO analysis of Department of Defense data. | GAO-19-336SP

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

- In 2018, two programs entered the portfolio and six exited. DOD approved the two entering programs for system development starts between January and December 2018. For five of the six exited programs, 90 percent of planned expenditures have been made. The Army terminated the remaining program, Warfighter Information Network—Tactical (WIN-T) Increment 3, due to affordability challenges and changes to the Army's network strategy.

Figure 4 shows programs entering and exiting the 2018 portfolio.

Figure 4: Programs that Entered and Exited the 2018 Portfolio



CH-47F Block II	CH-47F Modernized Cargo Helicopter
T-AO 205 Class	T-AO 205 John Lewis Class Fleet Replenishment Oiler
C-5 RERP	C-5 Reliability Enhancement and Re-engineering Program
MH-60R	MH-60R Multi-Mission Helicopter
WIN-T Inc 3	Warfighter Information Network-Tactical Increment 3
GBS	Global Broadcast Service
EPS	Enhanced Polar System
WGS	Wideband Global SATCOM

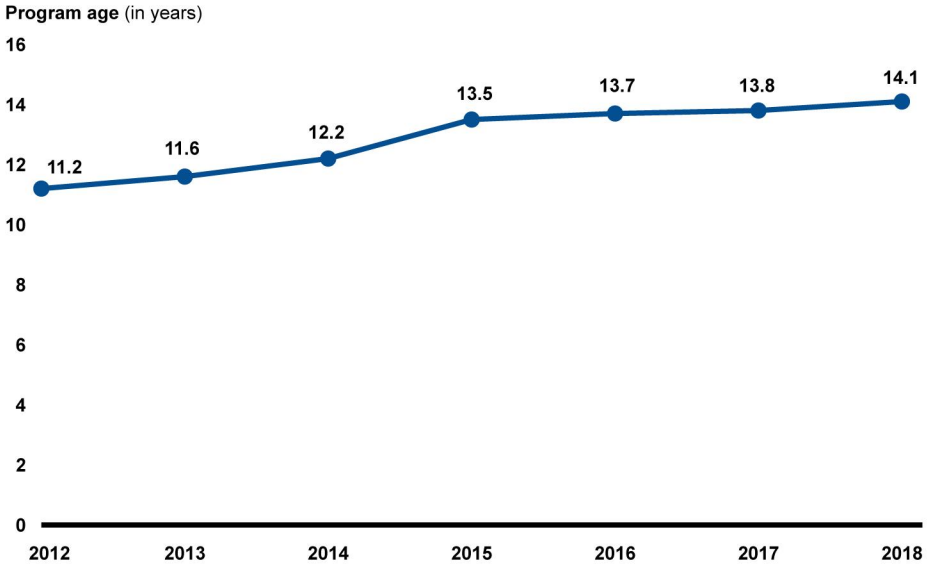
Source: GAO analysis of Department of Defense data. | GAO-19-336SP

Note: The two entering programs produced their first Selected Acquisition Reports in December 2017, while the six exiting programs produced their final Selected Acquisition Reports in December 2016.

Observation 2. The average age of programs in the portfolio has increased.

While the number of programs in the portfolio has declined since last year, the average age of the programs that have remained has steadily increased since 2012. The current portfolio is approximately 4 months older than last year's and nearly 3 years older than that from 2012. Figure 5 displays the increasing average age of programs in the portfolio since 2012.

Figure 5: Annual Change in Average Program Age in DOD's Portfolio of Major Defense Acquisition Programs, 2012-2018



Source: GAO analysis of Department of Defense data. | GAO-19-336SP

The growing portfolio age is a byproduct of multiple factors, including the following:

- DOD has introduced new capabilities and upgrades through additions to existing programs rather than by starting new programs—an approach inconsistent with best practices.[12] Best practices recommend an incremental approach in which new development

[12]GAO, *F-35 Joint Strike Fighter: Continued Oversight Needed as Program Plans to Begin Development of New Capabilities*, GAO-16-390 (Washington, D.C.: Apr. 14, 2016); GAO, *Arleigh Burke Destroyers: Delaying Procurement of DDG 51 Flight III Ships Would Allow Time to Increase Design Knowledge*, GAO-16-613 (Washington, D.C.: Aug 4, 2016).

efforts are structured and managed as separate acquisition programs with their own requirements and acquisition program baselines. If the effort is not established as a separate acquisition program, transparency is limited and it may be more difficult for Congress to hold the new effort accountable for achieving its cost, schedule, and performance requirements. MDAPs to which DOD has added warfighting capabilities under the existing program structure include the DOD-wide F-35 Lightning II Joint Strike Fighter and the Navy's P-8A, Arleigh Burke Class Destroyer (DDG 51), and Virginia Class Submarine (SSN 774).

- Twenty programs have remained in the DOD MDAP portfolio for more than 20 years. Programs using DOD's middle tier rapid prototyping and rapid fielding pathways, established pursuant to Section 804 of the fiscal year 2016 NDAA, are expressly excluded from the statutory definition of MDAP and therefore will not join the portfolio. For example, during the course of our review, six programs that DOD previously classified as pre-MDAPs are now proceeding via the alternate rapid prototyping and rapid fielding acquisition pathways. As newer programs choose this alternate path, the portfolio takes in fewer new programs than it otherwise would, which skews the average age of the portfolio toward older programs.

Observation 3. Future funding needs remain within historic norms.

- The current amount of future funding the portfolio needs decreased from $701.8 billion to $688.8 billion over the past year.[13] This decrease is largely due to a nearly $7 billion decrease in development and procurement costs since 2017 in the Army's WIN-T Increment 2 program, which the Army has descoped. For the 2018 portfolio, DOD has programmed $32.6 billion for development and $656.2 billion for procurement activities.
- Total development and procurement costs already invested in the portfolio have increased from $962 billion to $981 billion over the past year. Both invested and future funding needs remain within the historical norms.
- The Navy's 40 MDAPs comprise 46 percent of the portfolio, but are responsible for 60 percent of the portfolio's total invested development

[13]Future funding is the amount of investment the portfolio requires to complete all of its development activities and to procure all of its planned quantities.

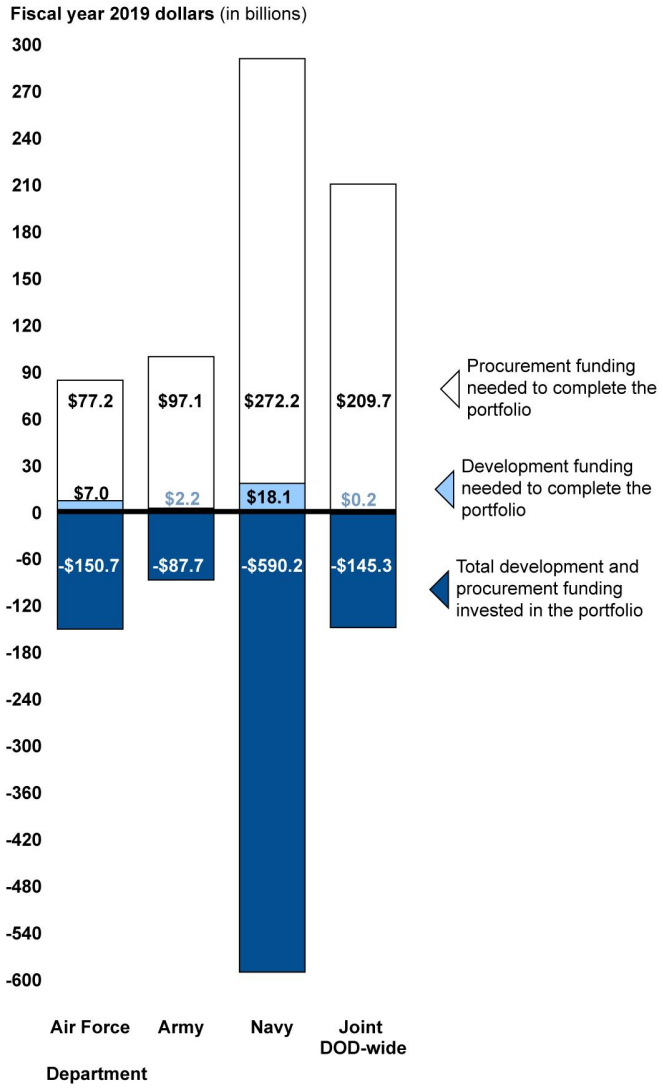
and procurement costs. In addition, the Navy's share of future portfolio costs will likely grow because of its plan to grow its fleet size by 25 percent, starting in fiscal year 2019 and continuing through 2048.[14]

- Importantly, our analysis of DOD's MDAP portfolio excluded classified programs, such as the Air Force's new B-21 Raider program.

Figure 6 displays the current portfolio's development and procurement funding (invested versus remaining) by military department.

[14]GAO, *Navy and Marine Corps: Rebuilding Ship, Submarine, and Aviation Readiness Will Require Time and Sustained Management Attention*, GAO-19-225T (Washington, D.C.: Dec 12, 2018).

Figure 6: Major Defense Acquisition Program Investments among Military Departments and DOD-wide within the 2018 Portfolio



Source: GAO analysis of Department of Defense data. | GAO-19-336SP

Note: The figure does not account for classified programs, which we excluded from our analyses. The figure also excludes $7.17 billion in spent development and procurement funding and $5.04 billion in development funding needed to complete the Chemical Demilitarization— Assembled Chemical Weapons Alternatives program managed by DOD.

A Small Number of Aging Programs Are Driving Portfolio Cost Growth

Observation 4. Over the past year, the total estimated acquisition cost of the portfolio increased by $26.6 billion, despite its net loss of four programs.

- One year of cost growth for the current, smaller portfolio (plus the addition of two new systems, the Army's CH-47F Block II and the Navy's T-AO 205) was large enough to offset the cost decrease that resulted from the aforementioned exit of six systems, one being the Navy's MH-60R Helicopter, with its estimated cost of $15 billion.
- Of the $26.6 billion increase, nearly $4 billion is in research and development funds, while $21 billion is attributed to procurement costs. The remainder ($1.6 billion) is for costs associated with acquisition-related operational maintenance and system-specific military construction activities.

Table 1 details the annual change to funding and average cycle times between 2017 and 2018 for initial capability delivery portfolios.

Table 1: Cost and Schedule Changes to DOD's 2018 Portfolio of 82 Major Defense Acquisition Programs over the Past Year (fiscal year 2019 dollars in billions)

	Estimated portfolio cost in 2017	Estimated portfolio cost in 2018	Estimated portfolio change since 2017	Percentage change since 2017
Total estimated research and development cost	300.50	304.47	3.97	1.3
Total estimated procurement cost	1,344.25	1,365.29	21.04	1.5
Total estimated acquisition cost	1,659.03	1,685.65	26.62	1.6
Average cycle time to deliver initial capabilities (in months)	120.1	121.9	1.8	1.5

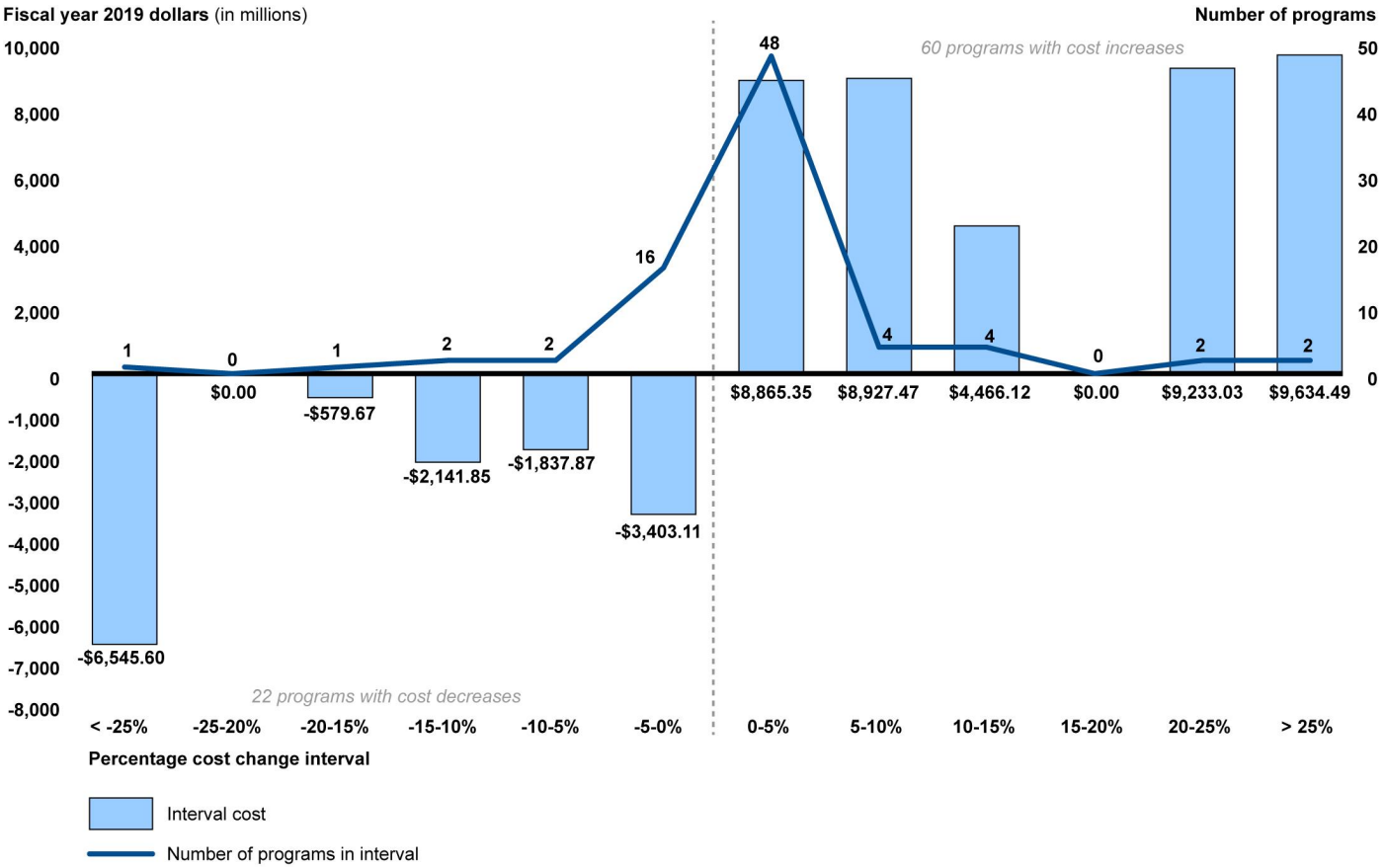
Source: GAO analysis of Department of Defense data. | GAO-19-336SP

Note: In order to make the two portfolios comparable, we added the first full estimates of the two entering programs to last year's portfolio and removed funding and schedule information of the six programs that exited the portfolio since last year.

See appendix V for program- and military department-specific cost performance information, including figures related to the performance of individual programs over the past year and since first full estimates.

- Over the past year, 60 programs experienced total acquisition cost increases totaling over $41 billion. While most programs realized an increase of less than 5 percent, total cost increases for three programs—the Navy's Ford Class Aircraft Carrier (CVN 78) and DDG 51 and the Army's Guided Multiple Launch Rocket Alternative Warhead System —comprise 60 percent, or nearly $25 billion, of the total growth. In all three cases, the preponderance of cost growth was caused by quantity increases.
- At the same time, 22 programs experienced total acquisition cost decreases, totaling $14.5 billion. The Army's WIN-T Increment 2 program quantity reductions accounted for $6.3 billion, or 43 percent, of that savings. The Army scaled down the program for the same reason it canceled WIN-T Increment 3—the platforms' inability to meet the Army's evolving networking needs. Figure 7 displays the portfolio's total acquisition cost change from 2017 to 2018 by percentage change intervals, irrespective of changes in quantity.

Figure 7: Total Acquisition Cost Increases and Decreases in Major Defense Acquisition Programs, 2017-2018



Source: GAO analysis of Department of Defense data. | GAO-19-336SP

In December 2008, we reached agreement with DOD and the Office of Management and Budget on a set of metrics, which we have used to assess DOD's performance since 2011. These metrics measure cost growth of DOD MDAPs since first full estimates and over the last 5-year and 1-year periods. Specifically, cost growth of less than 2 percent that occurs over a period of 1 year is "acceptable", while growth occurring over 5 years and since program initiation must fall below 10 and 15 percent, respectively, to meet metric goals.

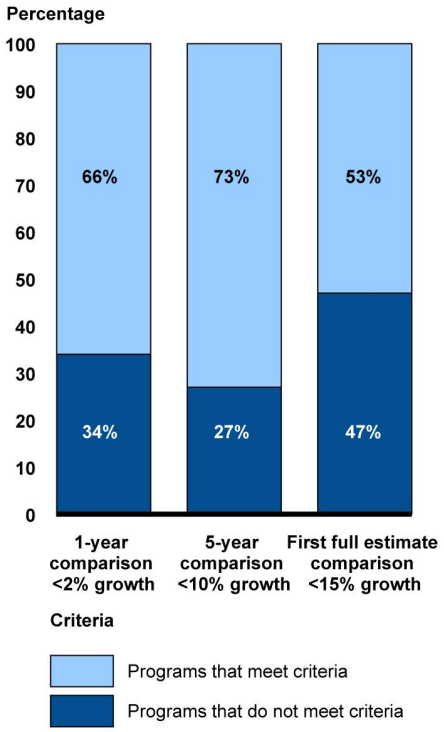
DOD officials stated the metrics are dated and do not reflect current thinking within the department for tracking cost growth. Consequently, they no longer endorse their use. We have yet to agree on an alternative way of measuring performance over the specified periods. Such metrics provide DOD with a means to monitor and independently validate the effectiveness and sustainability of corrective measures—key criteria

needed to remove DOD Weapon Systems Acquisition from our high-risk list.[15] In July 2018, DOD initiated discussions with us, which will continue in 2019, to develop a new set of agreed-upon metrics to track the portfolio's performance over time. We believe the metrics ultimately chosen should allow for the department to identify specific programs whose costs are approaching unacceptable levels and that may require added attention. Until then, we will continue to rely on the previous agreed-upon standards, which show that programs continue to fall short of the metric for acceptable cost growth over all three recognized periods.

Figure 8 presents the percentage of programs that satisfied the cost growth metrics. As the figure shows, programs have more successfully minimized cost growth over 1- and 5-year periods, as compared to cost growth since first full estimate. Appendix VI provides additional details on the portfolio's historic cost performance against these metrics.

[15]GAO-19-157SP.

Figure 8: Major Defense Acquisition Programs' Performance against Selected Cost Growth Metrics



Source: GAO Analysis of Department of Defense data. | GAO-19-336SP

MDAP Schedules and Costs Have Grown by 35 Percent and 51 Percent, Respectively, since First Full Estimates

Observation 5. Programs in the 2018 portfolio experienced a $569 billion increase in total acquisition cost since first full estimates and average schedule delays of more than 27 months, largely driven by aging programs. The majority of cost growth occurred after programs began production.

- Programs' average delay in delivering initial capabilities has increased by over 27 months since their first full estimates. Further, MDAPs show, on average, 51 percent total acquisition cost increase since their first full estimates, more than half of which is attributable to three programs—the Navy's DDG 51 and SSN 774 and the DOD-wide F-35 Lightning II Joint Strike Fighter.
- Programs that have been in the portfolio for over 20 years are the primary drivers of these outcomes. Within these programs, average

delays in initial capability exceed 36 months and cost changes from first full estimates have increased by over 83 percent. The portfolio's 20 oldest programs have amassed total acquisition cost growth of $474 billion since first full estimates. On the other hand, programs that have been in the portfolio for fewer than 10 years recorded decreasing costs of $3.4 billion since first full estimates and initial capability delays of less than 12 months.

Table 2 breaks down the portfolio's total acquisition cost and schedule changes since first full estimates, which are not adjusted for quantity changes.

Table 2: Portfolio Cost and Schedule Changes since Major Defense Acquisition Programs' First Full Estimates (fiscal year 2019 dollars in billions)

	Dollar change	Percentage change
Total research and development cost	103.49	51.5
Total procurement cost	461.42	51.0
Total other (military construction and operations and maintenance) acquisition cost	4.50	39.6
Total acquisition cost	569.41	51.0
Average delay in delivering initial capabilities (in months)	27.4	34.9

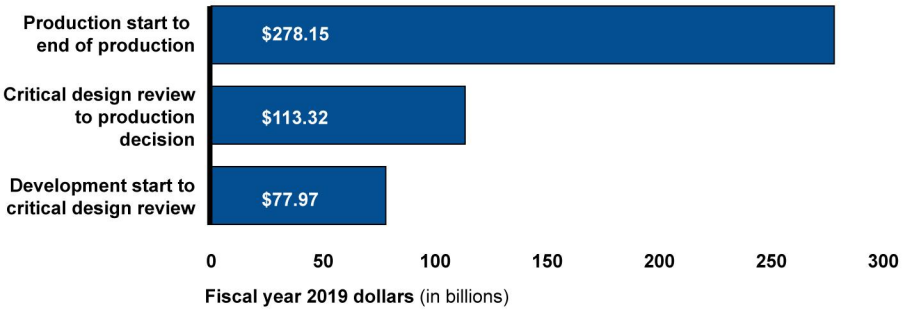
Source: GAO analysis of Department of Defense data. | GAO-19-336SP

While the current portfolio's costs have grown across all phases of the acquisition cycle, the majority of growth occurred after production start. As we have previously reported, cost growth during this acquisition phase may be symptomatic of programs entering production without attaining key knowledge about technology maturity, design stability, and production readiness.[16] We assess these parameters later in this report. Sixty-one of 82 portfolio programs are in production.

Figure 9 displays the current portfolio's cost growth across three acquisition phases.

[16]GAO, *Weapon Systems Annual Assessment: Knowledge Gaps Pose Risks to Sustaining Recent Positive Trends*, GAO-18-360SP (Washington, D.C.: Apr. 25, 2018).

Figure 9: Portfolio Cost Growth by Acquisition Phase (fiscal year 2019 dollars in billions)



Source: GAO analysis of Department of Defense data. | GAO-19-336SP

Note: In order 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.

Quantity Increases and Cost Reporting

In the cases of SBIRS High and AEHF, the Air Force increased quantities by two additional units late into each programs' acquisition cycle, which the Air Force called a "block buy." Each program reported separate cost and funding information for the block buys and eventually removed the first four satellite units in each program's Selected Acquisition Report after they were 90 percent complete. This reduced our visibility into each program's cost performance and, as a result, our numbers do not reflect DOD's total investment in them.

Source: GAO analysis of Department of Defense data. | GAO 19-336SP

Other contributing factors to high cost growth after programs enter production include increases in quantities or added capabilities after first full estimates are finalized. For example, satellite systems such as the Air Force's Space-Based Infrared System (SBIRS) High and the Advanced Extremely High Frequency (AEHF) added additional satellite units in the form of "block buy" subprograms well after the programs' first full estimates.

Programs' Cost Performance Varied Considerably When Controlling for Quantity Changes

Observation 6. For some programs, cost performance reversed when factoring in quantity changes.

We analyzed the total amount of acquisition cost changes, not due to quantity changes, since first full estimates. We then ranked the programs in terms of highest and lowest performing, by both total dollars and total percentage, in tables 3 and 4 below.

- Navy programs showed the widest variability in cost changes, with the best performing program and the second-worst performing program when adjusted for quantities.
- Some programs showed improved cost performance when we accounted for quantity changes, as was the case of the Navy's DDG 51 program. This program was one of three that drove overall portfolio cost growth since first full estimate. Yet, when we accounted for

quantity changes, our analysis showed program cost reductions of more than $25 billion since first full estimate. Likewise, the Air Force Joint Direct Attack Munition (JDAM) program's unadjusted total cost growth since first full estimate is almost $8.8 billion. When adjusted for quantities, it had a cost reduction of more than $3.3 billion since its first full estimate.

- At least one program, the Navy's DDG 1000, showed decreased costs, but not at a rate commensurate with the decreased quantities. In 1997, the Navy set an initial baseline for the program that required a quantity of 32 ships. In 2008, the Navy truncated the program at three ships. This substantial reduction in quantity has driven an overall reduction in program costs totaling $13.5 billion. Nonetheless, the Navy is now only procuring three ships for what it originally planned to spend on 20 ships.

Tables 3 and 4 rank the 82 current MDAPs by the 10 programs with the lowest and highest total acquisition cost changes—unrelated to quantity changes—since programs' first full estimates. Table 3 ranks the programs by changes in total dollars, while Table 4 ranks the programs by total percentage changes.

Table 3: Ten Major Defense Acquisition Programs with the Lowest and Highest Total Acquisition Cost Change since First Full Estimates (fiscal year 2019 dollars in millions)

10 Programs with the Lowest Total Acquisition Cost Changes Since First Full Estimate

Rank	Program name	Cost change	Lead component	Program start date
1.	DDG 51	-$25,066.81	Navy	5/15/1983
2.	KC-46A	-$7,851.91	Air Force	2/15/2011
3.	Multifunctional Information Distribution System	-$5,039.60	Navy	12/15/1993
4.	Joint Direct Attack Munition	-$3,346.45	Air Force	10/15/1993
5.	Joint Light Tactical Vehicle	-$2,761.52	Army	12/22/2007
6.	Airborne & Maritime/Fixed Station	-$2,407.79	Army	12/15/2007
7.	CVN 78	-$2,213.62	Navy	4/23/2004
8.	HC/MC-130 Recap	-$1,577.44	Air Force	2/15/2010
9.	AH-64E New Build	-$930.40	Army	7/15/2010
10.	AIM-9X Blk II	-$871.69	Navy	6/15/2011

10 Programs with the Highest Total Acquisition Cost Changes Since First Full Estimate

Rank	Program name	Cost change	Lead component	Program start date
1.	F-35	$147,689.74	Joint Department of Defense-(DOD) wide	11/15/1996
2.	V-22	$40,945.63	Navy	12/15/1982
3.	Evolved Expendable Launch Vehicle	$39,607.54	Air Force	12/15/1996
4.	SSN 774	$34,542.19	Navy	8/15/1994
5.	DDG 1000	$19,451.31	Navy	12/15/1997
6.	Trident II	$16,068.45	Navy	10/15/1977
7.	Advanced Medium Range Air-to-Air Missile	$13,427.50	Air Force	11/15/1978
8.	UH-60M Black Hawk	$11,786.87	Army	4/15/2001
9.	Guided Multiple Launch Rocket System and Alternate Warhead	$11,234.73	Army	3/15/1998
10.	Chemical Demilitarization—Assembled Chemical Weapons Alternatives	$10,783.10	Joint DOD-wide	3/31/1998

Source: GAO analysis of Department of Defense data. | GAO-19-336SP

Table 4: Ten Major Defense Acquisition Programs with the Lowest and Highest Total Acquisition Cost Percentage Change since First Full Estimates

10 Programs with the Lowest Total Acquisition Cost Percentage Changes since First Full Estimate

Rank	Program name	Percentage change	Lead component	Program start date
1	Multifunctional Information Distribution System	-345	Navy	12/15/1993
2	DDG 51	-147	Navy	5/15/1983
3	Joint Direct Attack Munition	-87	Air Force	10/15/1993
4	AH-64E New Build	-35	Army	7/15/2010
5	Airborne & Maritime/Fixed Station	-26	Army	12/15/2007
6	AIM-9X Blk II	-19	Navy	6/15/2011
7	HC/MC-130 Recap	-17	Air Force	2/15/2010
8	KC-46A	-16	Air Force	2/15/2011
9	B61 Mod 12 LEP TKA	-15	Air Force	11/15/2012
10	Small Diameter Bomb II	-14	Air Force	7/29/2010

10 Programs with the Highest Total Acquisition Cost Percentage Changes since First Full

Rank	Program name	Percentage change	Lead component	Program start date
1	Guided Multiple Launch Rocket System and Alternate Warhead	567	Army	3/15/1998
2	Chemical Demilitarization—Assembled Chemical Weapons Alternatives	364	Joint Department of Defense-(DOD) wide	3/31/1998
3	CH-47F	280	Army	11/15/1997
4	MQ-1C Gray Eagle	263	Army	4/15/2005
5	H-1 Upgrades	216	Navy	9/15/1996
T6	Littoral Combat Ship	204	Navy	5/15/2004
T6	Evolved Expendable Launch Vehicle	204	Air Force	12/15/1996
8	Ground/Air Task Oriented Radar	111	Navy	3/15/2005
9	Advanced Medium Range Air-to-Air Missile	110	Air Force	11/15/1978
10	MQ-9 Reaper	108	Air Force	2/15/2004

Source: GAO analysis of Department of Defense data. | GAO-19-336SP

Appendix VII contains an expanded set of rankings that utilize the same criteria as the tables above, but identifies the best/worst performing five programs within each individual military department.

Programs Initiated Since 2010 Continue to Outperform Others, but Positive Performance Continues to Slow

Observation 7. Programs initiated since 2010 have realized a total acquisition cost increase of $1.4 billion since last year, whereas last year we found no growth in these programs. Those initiated before 2010 recorded an increase of $25.2 billion over the same period.

Table 5 outlines changes in both the total estimated acquisition cost and the average cycle time to deliver initial capabilities for the programs initiated before and since 2010.

Table 5: Programs' Total Acquisition Cost and Cycle Time Changes, 2017 to 2018 (fiscal year 2019 dollars in billions)

		Estimated portfolio cost in 2017	Estimated portfolio cost in 2018	Estimated portfolio change since 2017	Percentage change since 2017
Programs initiated since 2010	Total estimated research and development cost	55.71	57.07	1.36	2.4
	Total estimated procurement cost	219.18	219.06	-0.11	-0.1
	Total estimated acquisition cost	278.41	279.84	1.43	0.5
	Average cycle time to deliver initial capabilities (in months)	92.2	93.7	1.5	1.6
Programs initiated before 2010	Total estimated research and development cost	244.79	247.40	2.61	1.1
	Total estimated procurement cost	1,125.07	1,146.22	21.15	1.9
	Total estimated acquisition cost	1,380.61	1,405.80	25.19	1.8
	Average cycle time to deliver initial capabilities (in months)	134.8	136.5	1.7	1.3

Source: GAO analysis of Department of Defense data. | GAO-19-336SP

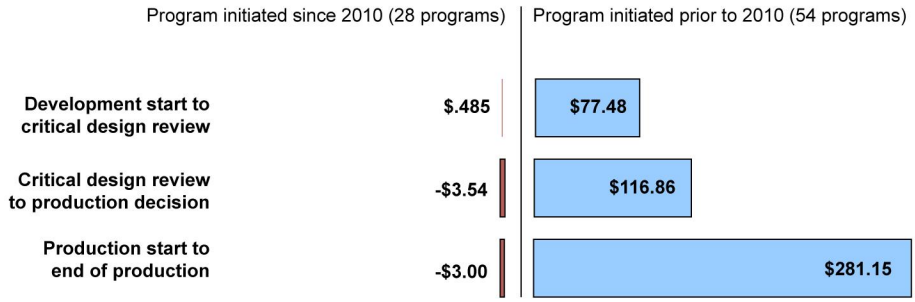
While the two groups of programs initiated before and since 2010 both experienced total acquisition cost increases since last year, the percentage increase for older programs is more than triple that of the newer programs. This performance disparity supports the observation from prior years that acquisition reforms, namely the Weapon Systems Acquisition Reform Act of 2009 and three Better Buying Power initiatives,

have driven reduced cost growth.[17] On the other hand, the cost growth now realized by the newer programs reflects a reversal since our prior assessment, when this group showed overall cost decreases. Over the past year, we observed a total of $1.4 billion in cost growth among these newer programs. Thus, instead of helping offset cost increases within the portfolio, as they have done in the past, newer programs directly contributed to the portfolio's cost growth between 2017 and 2018.

Similarly, while newer programs continue to minimize short-term cost growth more efficiently than older programs, that effectiveness has diminished. In particular, newer programs as a whole show additional cost growth between development start and critical design review (CDR) than in our prior assessment. This is likely because half of the newer programs have already passed, or are approaching, CDR. Figure 10 shows the cost performance by phase for both newer and older programs, as measured since first full estimate.

Figure 10: Programs' Total Acquisition Cost Changes since First Full Estimate by Acquisition Phases

Fiscal year 2019 dollars (in billions)



Source: GAO analysis of Department of Defense data. | GAO-19-336SP

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.

Our analysis further showed that:

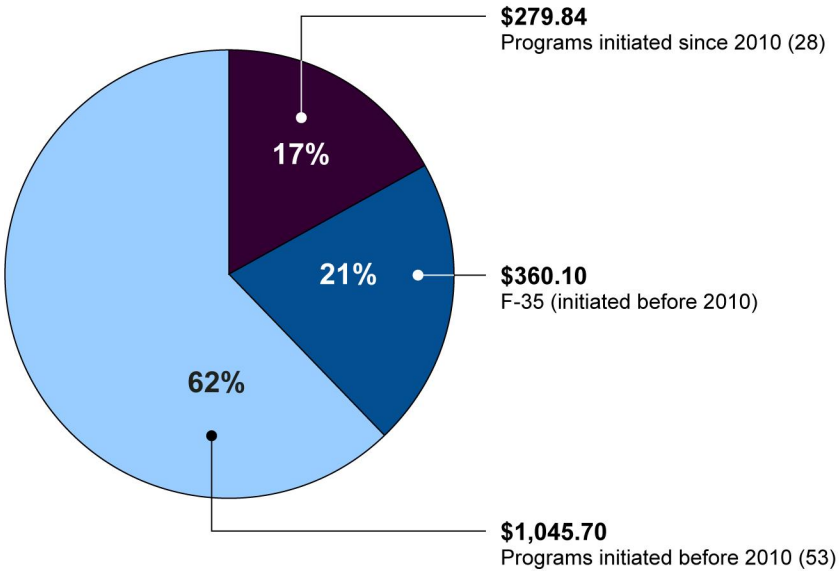
[17]Weapon Systems Acquisition Reform Act of 2009, Pub. L. No. 111-23; Between 2010 and 2015, the Under Secretary of Defense for Acquisition, Technology, and Logistics implemented "Better Buying Power" initiatives based on the principle that continuous improvement is the best approach to improving the performance of the defense acquisition enterprise.

- Overall, the current cost estimates for the 28 programs initiated since 2010 have decreased from their first full estimates, which is illustrated above as cost decreases incurred after both CDR and production start. While we acknowledge the decreases in projected future spending, only 15 of the 28 since-2010 programs have conducted their CDR, and only 11 are in production, which is the phase where cost growth has historically been the greatest. At this point, it is unclear whether the newer programs can maintain lower spending projections as they proceed through the acquisition process.
- Despite the positive changes to cost projections beyond CDR and production for since-2010 programs, those same programs reported cost growth of $485 million between development start and CDR, almost doubling the growth we identified last year over the same acquisition timeframe.
- In comparison, cost growth reported by the 54 programs initiated prior to 2010 occurred during all phases of the acquisition process, with the vast majority occurring after CDR or start of production.

Figure 11 illustrates how the current portfolio's total acquisition cost is apportioned between older programs that were initiated prior to 2010, newer ones initiated since 2010, and the F-35 Lightning II Joint Strike Fighter—DOD's largest acquisition program, initiated in 2001.

Figure 11: Distribution of Total Acquisition Costs among Various Groups of Programs

Fiscal year 2019 dollars (in millions)



Source: GAO Analysis of Department of Defense data. | GAO-19-336SP

- The deteriorating performance of newer programs can also be seen in their diminished buying power gains. 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 it may still experience a buying power gain or loss.
- While newer, post-2010 programs still recorded a buying power gain of $263 million since last year, it is merely a fraction of past gains. For instance, post-2010 programs' buying power gains amounted to nearly $5 billion in 2017.
- On the other hand, the portfolio's overall buying power gain of $3.9 billion was largely driven by the performance of older programs, 16 of which experienced a combined buying power increase of nearly $11 billion.

Table 6 showcases buying power changes across the two groups of programs. Negative numbers indicate decreased costs and a gain in buying power, while positive numbers indicate the opposite.

Table 6: Buying Power Changes Since 2017 (fiscal year 2019 dollars in millions)

Buying Power since 2017 for Programs Initiated before 2010

	Number of programs	Actual procurement cost change	GAO calculated cost change attributable to quantity changes	GAO calculated cost change not attributable to quantity changes
Increased buying power	**16**	**9,525.75**	**20,508.76**	**-10,983.01**
Procurement cost decreased with no quantity change	7	-4,178.24	0.00	-4,178.24
Quantity increased with less cost increase than anticipated	8	20,299.79	26,812.46	-6,512.67
Quantity decreased with more cost decrease than anticipated	1	-6,516.96	-6,303.70	-213.26
Decreased buying power	**36**	**11,621.06**	**4,352.69**	**7,268.37**
Procurement cost increased with no quantity change	23	3,213.37	0.00	3,213.37
Quantity increased with more cost increase than anticipated	6	11,534.59	9,511.20	2,023.39
Quantity decreased with less cost decrease than anticipated	7	-3,205.74	-5,158.51	1,952.77
No change in buying power	**2**	**0.00**	**0.00**	**0.00**
Sub-portfolio Totals	**54**	**21,146.81**	**24,861.45**	**-3,714.64**

Buying Power since 2017 for Programs Initiated since 2010

	Number of programs	Actual procurement cost change	GAO calculated cost change attributable to quantity changes	GAO calculated cost change not attributable to quantity changes
Increased buying power	**9**	**-1,178.12**	**76.92**	**-1,255.04**
Procurement cost decreased with no quantity change	6	-1,064.50	0.00	-$1,064.50
Quantity increased with less cost increase than anticipated	2	55.46	173.81	$118.35
Quantity decreased with more cost decrease than anticipated	1	-169.08	-96.89	$72.19
Decreased buying power	**17**	**1,066.87**	**75.02**	**991.85**

	Number of programs	Actual procurement cost change	GAO calculated cost change attributable to quantity changes	GAO calculated cost change not attributable to quantity changes
Procurement cost increased with no quantity change	16	952.58	0.00	952.58
Quantity increased with more cost increase than anticipated	1	114.29	75.02	39.27
Quantity decreased with less cost decrease than anticipated	0	0.00	0.00	0.00
No change in buying power	**2**	**0.00**	**0.00**	**0.00**
Sub-portfolio Totals	**28**	**-111.25**	**151.94**	**-263.19**
Portfolio Totals	**82**	**21,035.56**	**25,013.39**	**-3,977.83**

Source: GAO analysis of Department of Defense data. | GAO-19-336SP

DOD MDAPs Operate in an Environment of Limited Competition and a Constrained Defense Contractor Base

Observation 8. Current MDAPs did not compete 67 percent of their currently reported major development and procurement contracts.

We have reported that competition is the cornerstone of a sound acquisition process and a critical tool for achieving the best return on investment for taxpayers. [18] Generally, a low competition rate can contribute to increased costs of goods and services and decreased buying power. According to the Office of Federal Procurement Policy, “ineffective competition”—when one offer is received in response to a competitive solicitation—deprives the programs and their managing agencies of the ability to consider alternative solutions in a reasoned and structured manner, thereby creating opportunities for increased costs, substandard products and prolonged acquisition cycles. In July 2009, the Office of Management and Budget (OMB) issued a memorandum to department and agency heads in which it categorized noncompetitive contracts as high-risk because, absent competition, agencies must negotiate contracts without the benefit of a direct market mechanism to help set the contract price.

Our prior work has identified various factors that affect competition rates, including the government’s preference for a specific vendor, inadequate acquisition planning, and overly restrictive government requirements.

[18]GAO, *Defense Contracting: Early Attention in the Acquisition Process Needed to Enhance Competition*, GAO-14-395 (Washington, D.C.: May 5, 2014).

Moreover, we identified DOD-specific factors, such as reliance on original manufacturers and entry barriers resulting from the complexity of DOD's contracting process and lack of data rights—legal rights a contractor and/or the government have to use technical, intellectual property and software data—as contributing to DOD's particularly low competition rates.[19]

Creation and sustainment of competitive environments was a recurring theme in DOD's Better Buying Power policy memorandums issued between 2010 and 2015. In order to analyze DOD's performance in generating competition in contracting within the 2018 MDAP portfolio, we compiled a list of all 183 active major contracts and orders identified in individual programs' 2017 SARs and compared them to information in the FPDS-NG database.[20] All but three of these contracts and orders were for development or procurement.[21] Of the 183 contracts and orders included in our review:

- the department awarded 180 for development and procurement efforts,
- the Navy awarded 85 contracts that totaled $147.1 billion,
- the Air Force awarded 51 contracts that totaled $132.6 billion,
- the Army awarded 37 contracts that totaled $50.5 billion, and
- Joint, DOD-wide offices awarded 10 contracts that totaled $33.8 billion.

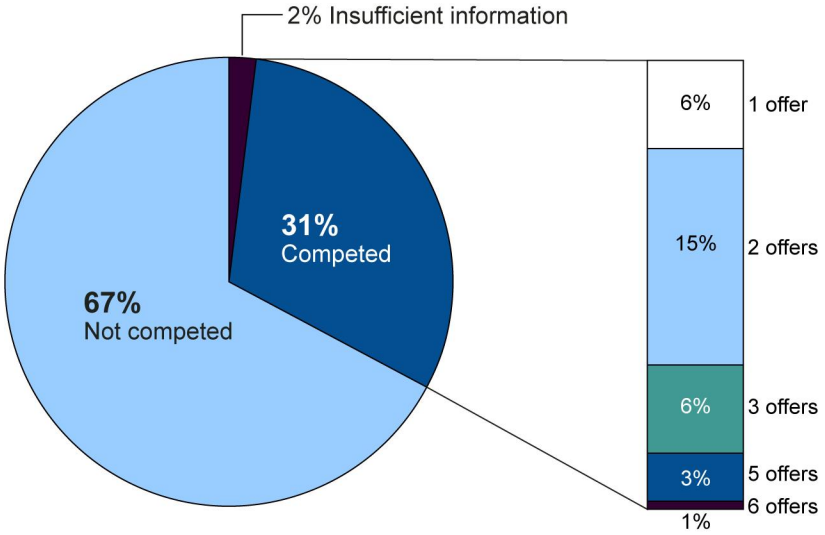
[19]GAO, *Federal Acquisitions: Congress and the Executive Branch Have Taken Steps to Address Key Issues, but Challenges Endure,* GAO-18-627 (Washington, D.C.: Sept. 12, 2018).

[20] By statute, SARs include an MDAP's "major contracts," which are defined as "each of the six largest prime, associate, or Government-furnished equipment contracts under the program that is in excess of $40,000,000 and that is not a firm, fixed price contract." An MDAP's SAR requirements cease after 90 percent of the total quantity of items to be purchased under the program are delivered or 90 percent of planned expenditures are made. DOD guidance states that once a contract is 90 percent complete, it is no longer reported in the SAR.

[21] Of the 183 contracts and orders in our analysis, DOD reporting indicated that 115 were for procurement; 65 were for research, development, test, and evaluation; two were for acquisition-related operations and maintenance; and one was for system-specific military construction.

Figure 12 shows the percentage of the 183 contracts in our analysis that DOD either competed or did not compete, as well as the reported number of offers DOD received for each category. Appendix II provides more details on the selection of contract actions included in this analysis, as well as how we define “competitive” and “non-competitive” actions.

Figure 12: Competition in Currently Reported Major Contracts and Number of Offers Received



Source: GAO analysis of Federal Procurement Data System—Next Generation data. | GAO-19-336SP

Note: In order to analyze DOD’s performance in generating competition in contracting within the 2018 major defense acquisition program portfolio, we compiled all 183 contracts listed on individual programs’ 2017 SARs and compared them to information in the Federal Procurement Data System-Next Generation database.

Federal statutes and acquisition regulations generally require that contracts be awarded on the basis of full and open competition. However, they also permit agencies to award noncompetitive contracts in certain circumstances, such as:

- only one responsible source and no other supplies or services will satisfy agency requirements;
- unusual and compelling urgency; and

- when authorized or required by statute (for example, sole source awards to small businesses.)[22]

Additionally, Federal Acquisition Regulation (FAR) part 34, which establishes policies for the acquisition of major systems, directs agencies and program managers to promote and sustain effective competition among alternative system concepts and sources for "as long as it is economically beneficial and practicable to do so."[23] Thus, the FAR reflects that there may be a point in a major system acquisition at which promoting and sustaining competition among alternative sources is no longer economically beneficial and practicable.

Our analysis of the 183 contract awards also found the following:

- Competition rates for research and development contract awards were considerably higher, at 81 percent competed, than those for procurement contract awards, where the competition rate was barely over 15 percent. This dichotomy may be linked to the government's tendency to rely on original weapon systems equipment manufacturers for follow-on procurements, to include sustainment contracts.[24]
- In March 2017, we reported on overall trends in defense and civilian agencies' contract obligations, such as trends in competition.[25] In that report, we noted that DOD produces annual competition reports,

[22]FAR §§ 6.302-1, 6.302-2, 6.302-5.

[23]FAR §§ 34.002(b), 34.005-1(a). In FAR part 34, "effective competition" is defined as "a market condition that exists when two or more contractors, acting independently, actively contend for the Government's business in a manner that ensures that the Government will be offered the lowest cost or price alternative or best technical design meeting its minimum needs." FAR § 34.001.

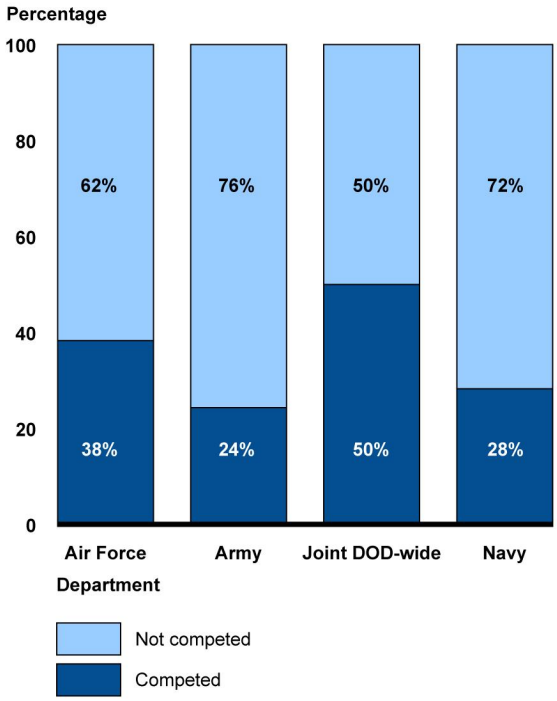
[24]The additional systems or sustainment are often procured through contract modifications or the exercise of contract options. This situation is partly attributable to the unique relationship that DOD has with the defense industry that differs from the commercial marketplace. The combination of a single buyer (DOD), few very large prime contractors in each segment of the industry, and a limited number of weapon programs constitutes a structure for doing business that is altogether different from a classic free market. For instance, there is less competition and once a contract is awarded, the contractor often remains the sole vendor capable of providing additional systems and sustainment. These long-term contractual relationships with weapon system contractors limit opportunities for competition. See GAO-14-395.

[25]GAO, *Contracting Data Analysis: Assessment of Government-wide Trends,* GAO-17-244SP (Washington, D.C.: Mar. 9, 2017).

which recognize that competition achievement varies by organization based on the mission and types of products and services being procured. For example, competition rates are lower in organizations that buy major weapon systems—such as those covered in this annual assessment—particularly as systems move into production.

Figure 13 displays the percentage of the 183 contracts that DOD awarded competitively and noncompetitively—by military department and Joint, DOD-wide—we analyzed.

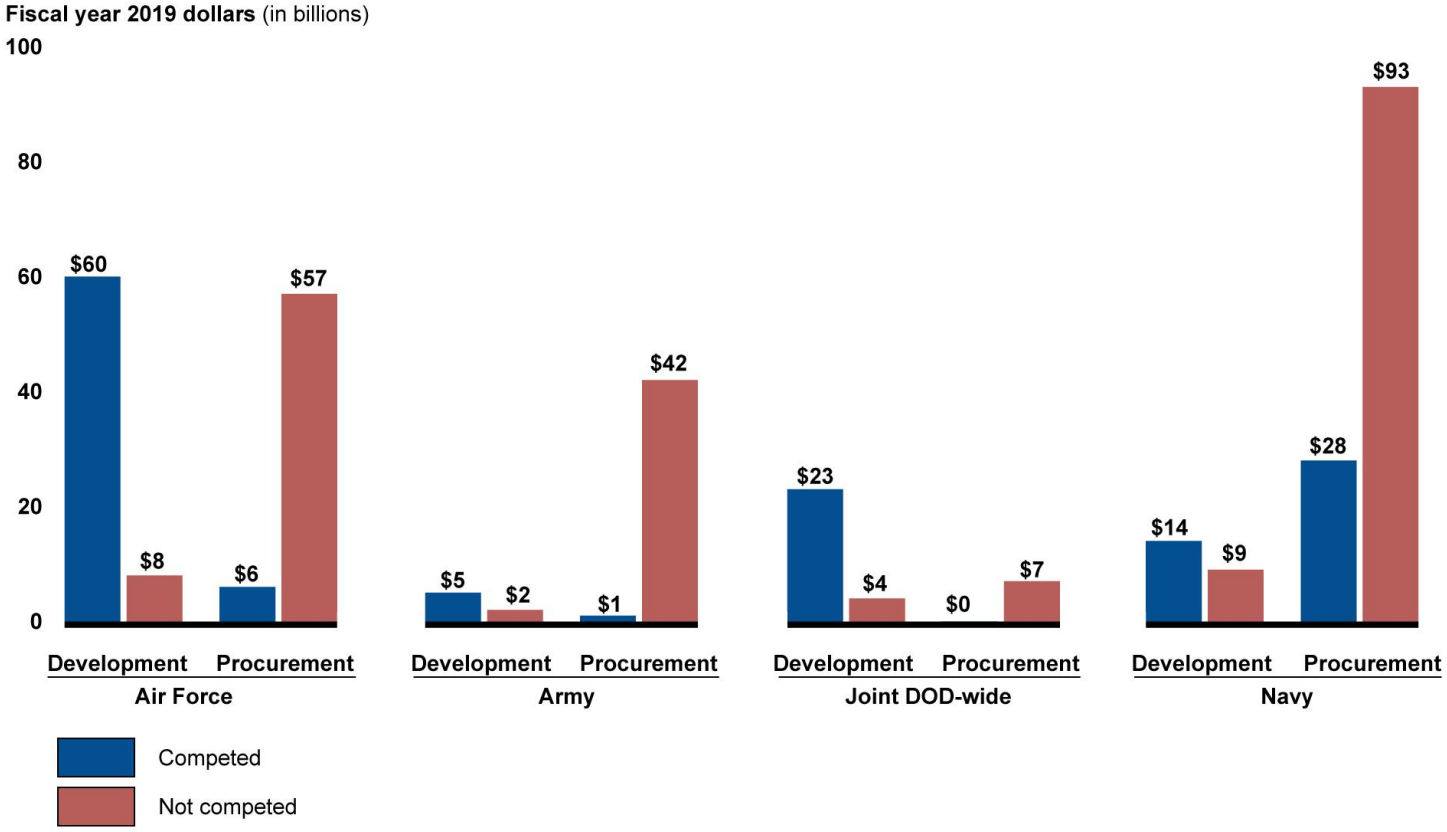
Figure 13: Competition Rates for 183 Currently Reported Major Contract Awards within DOD's 2018 Portfolio of Major Defense Acquisition Programs



Source: GAO analysis of Federal Procurement Data System—Next Generation data. | GAO-19-336SP

Figure 14 shows total dollar amounts of 180 major development and procurement contracts that DOD awarded competitively and noncompetitively—by military department and Joint, DOD-wide.

Figure 14: Dollars Associated with Competition Results for 180 Currently Reported Major Development and Procurement Contract Awards within DOD's 2018 Portfolio of Major Defense Acquisition Programs



Source: GAO analysis of Federal Procurement Data System—Next Generation data. | GAO-19-336SP

A Small Group of Contractors Received the Majority of MDAP Contract Award Dollars

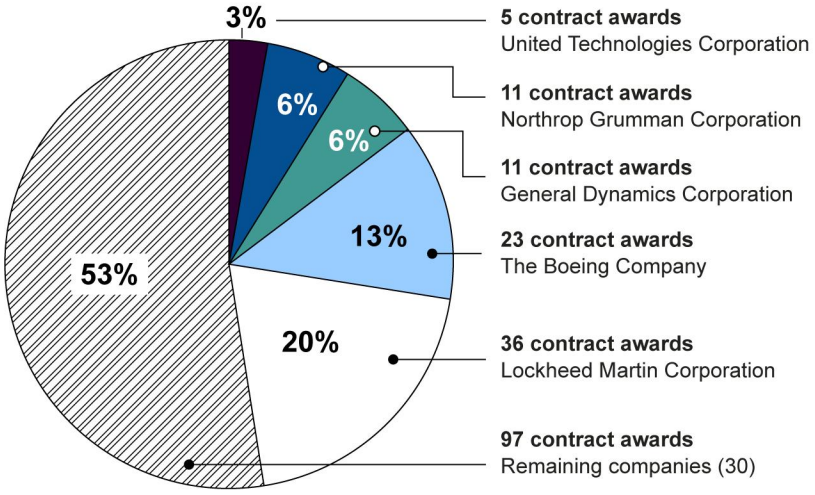
Observation 9. DOD awarded 47 percent of its currently reported 183 major development and procurement contract awards to five corporations and entities connected with them. This 47 percent constituted 72 percent of the dollars associated with the 183 major contracts; the remaining 28 percent was distributed among 30 other companies.

- Of the 183 major contract awards we analyzed, five corporations and entities connected with them received a combined 86 awards totaling over $262 billion. The prime contractors are Boeing, Lockheed Martin,

General Dynamics, United Technologies, and Northrop Grumman. DOD awarded 97 contracts totaling almost $100 billion to 30 other companies.

Figure 15 shows how DOD divided the 183 contract awards we reviewed among the top five prime contractors and remaining companies. Figure 16 shows the total dollars associated with these contract awards by prime contractor.

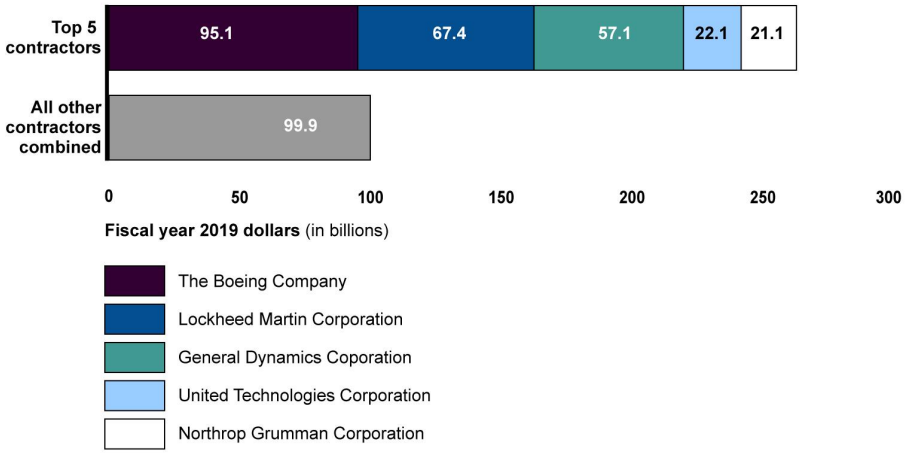
Figure 15: Distribution of Contract Awards among Prime Contractors for 183 Currently Reported Major Contracts within DOD's 2018 Portfolio of Major Defense Acquisition Programs



Source: GAO analysis of Federal Procurement Data System—Next Generation data. | GAO-19-336SP

Note: Percentages for each of the five prime contractors identified in the figure also include awards to entities connected with them. Values may not sum to 100 percent due to rounding.

Figure 16: Distribution of Dollars among Prime Contractors for 183 Currently Reported Major Contracts within DOD's 2018 Portfolio of Major Defense Acquisition Programs



Source: GAO analysis of Federal Procurement Data System—Next Generation data. | GAO-19-336SP

Notes: Dollar values for each of the five prime contractors identified in the figure also include those from entities connected with them. These contract values include the base contract and all options, regardless of whether the option has been, or will be, exercised.

Our Observation on DOD's Application of Key Acquisition Reforms

Our analysis of questionnaire responses from 51 MDAPs shows that these programs have applied, to varying degrees, six selected acquisition reforms included in NDAAs between fiscal years 2016 and 2018. We completed this analysis to identify the extent to which reforms have taken hold across DOD, not to evaluate programs' compliance in implementing them. Prior to passage of these newer acquisition reforms, numerous programs had already taken steps related to the areas addressed by some of the reforms. For instance, many programs that were well into either development or production had crafted an acquisition strategy that called for the use of a modular, open-systems design prior to the related reform described below. Others had previously established goals for numerous acquisition elements, such as procurement unit costs, sustainment costs, and an initial operational capability date. However, these reforms are still relatively new, and hence will apply primarily to newer systems that have yet to begin development. In other cases, the reforms offer options—as opposed to requirements—for the department and programs to consider utilizing during program execution.

Observation 1. Six acquisition reforms we reviewed have gained varying degrees of traction within the 51 programs we surveyed; even though many of these programs predate these reforms, programs have taken action in areas related to the reforms.

Forty-five of the 51 programs are well into either development or production and beyond several of the key acquisition phases where application of many of the reforms might be expected to occur. At the same time, most, but not all, of the six reforms we reviewed built upon concepts that already existed in policy or law. For example, DOD's Better Buying Power initiatives have emphasized the use of modular, open systems architecture.

Table 7 presents an overview of the six acquisition reforms we included in our analysis. Appendix IV contains more detailed descriptions of these acquisition reforms.

Table 7: Overview of Selected, Recent Acquisition Reforms

Legislative provision	Name of reform	Description
Fiscal Year (FY) 2016 National Defense Authorization Act (NDAA) § 804	Middle tier of acquisition for rapid prototyping and rapid fielding	Calls for the Department of Defense (DOD) to issue guidance for a "middle tier" of acquisition programs to be completed in two to five years through two types of "acquisition pathways:" rapid prototyping and rapid fielding.
FY 2016 NDAA § 806	Secretary of Defense waiver of acquisition laws to acquire vital national security capabilities	Authorizes the Secretary of Defense to waive any provision of certain types of acquisition laws and regulations to, among other things, meet vital national security needs.
FY 2016 NDAA § 823[a]	Revision of Milestone A decision authority responsibilities for major defense acquisition programs (MDAP)	Requires a milestone decision authority to make various written determinations before granting Milestone A approval, including that an MDAP: (1) fulfills an approved Initial Capabilities Document, (2) is being developed in light of appropriate market research, (3) has a risk reduction plan for any identified areas of risk (4) addresses sustainment planning, and (5) has a cost estimate and the level of resources is sufficient for successful program execution.
FY 2017 NDAA § 805	Modular, open-systems approach in development of MDAPs	Requires that MDAPs that receive Milestone A or Milestone B approval after January 1, 2019 must be designed and developed, to the maximum extent practicable, with a modular, open-systems approach to enable incremental development and enhance competition, innovation, and interoperability.

Legislative provision	Name of reform	Description
FY 2017 NDAA § 807	Cost, schedule and performance goals of MDAPs[b]	Requires that (1) DOD set goals for MDAPs': a) procurement unit cost, b) sustainment costs, c) initial operational capability date, d) technology maturity, and e) prototyping, and (2) ensure that MDAPs complete an independent technical risk assessment[c]
FY 2018 NDAA § 864	Other transaction (OT) authority for certain prototype projects	Increased the service acquisition executive and Under Secretary of Defense approval thresholds for use of OTs for prototype projects to $100 million and $500 million, respectively.

Source: GAO analysis of the NDAAs for fiscal years 2016-2018 and of MDAP responses to GAO's questionnaire. | GAO-19-336SP

[a] Prior legislation required a milestone decision authority to certify to some of the same or similar elements as those in FY2015 NDAA § 823. See 10 U.S.C. 2366a (2014), amended by FY17 NDAA, Pub. L. No. 114-92, § 823 (2015).

[b] We did not include Air Force systems within the tallies for this acquisition reform.

[c] We collected data associated with this acquisition reform, but later identified information that led us to conclude this data is unreliable. As a result, we excluded this information from our analysis and we will obtain this information for future reporting.

Table 8 illustrates instances where programs reported taking actions in an area addressed by the acquisition reforms. In certain cases, these actions preceded the reforms.

Table 8: Actions in Areas Related to Recent Acquisition Reforms as Reported by 51 Current and Future Major Defense Acquisition Programs (MDAP)

Areas addressed by acquisition reform	Number of MDAPs that reported actions in the area
Secretary of Defense waivers of acquisition laws and regulations	3
Revision of milestone A decision authority responsibilities for MDAPs, to include milestone decision authority	6
written determinations that the program	
1. fulfilled an approved Initial Capabilities Document,	5
2. is being developed in light of appropriate market research,	8
3. has a risk reduction plan in place for any identified areas of risk	8
4. addresses sustainment planning, and	7
5. has a cost estimate and the level of resources is sufficient for successful program execution[a]	
Modular, open-systems approach in development of MDAPs	33

Areas addressed by acquisition reform	Number of MDAPs that reported actions in the area
Cost, schedule, and performance goals of MDAPs':	22
a. procurement unit cost,	21
b. sustainment costs,	29
c. initial operational capability date,	12
d. technology maturity, and	7
e. prototyping,	—
and ensure that MDAPs complete an independent technical risk assessment	
Other transactions authority for certain prototype projects	2
Middle tier of acquisition for rapid prototyping and rapid fielding[b]	0

Source: GAO analysis of Department of Defense data. | GAO-19-336SP

[a] Prior legislation required a milestone decision authority to certify to some of the same or similar elements as those in FY2015 NDAA § 823. See 10 U.S.C. 2366a (2014), amended by FY17 NDAA, Pub. L. No. 114-92, § 823 (2015). While many programs provided questionnaire responses regarding areas addressed by the acquisition reforms, only 22 current MDAPs reported having held a milestone A review. Further, only one program (Improved Turbine Engine Program) held its milestone A review after enactment of the FY16 NDAA. One pre-MDAP (Precision Strike Missile) was initiated at milestone A, and this also occurred after enactment of the FY16 NDAA.

[b] The statute that defines what constitutes an MDAP states that MDAPs do not include programs or projects carried out using the middle tier rapid prototyping or rapid fielding acquisition pathway. 10 U.S.C. § 2430(a)(2)(A). However, section 804 of the FY16 NDAA contemplates that the rapid prototyping pathway will include a process for transitioning successful prototypes to new or existing programs for production and fielding, under either the rapid fielding pathway or the traditional acquisition system. FY16 NDAA, Pub. L. No. 114-92, § 804 (2015) (codified, as amended, at 10 U.S.C. § 2302 note).

Some examples of programs' reports regarding areas addressed by these acquisition reforms include the following:

- The Army's Improved Turbine Engine Program was the only program among 45 current MDAPs we surveyed that was scheduled to enter system development after January 1, 2019. The program reported having an acquisition strategy with a modular, open-systems approach, as well as applying many features in the acquisition reform provisions cited in our questionnaire.
- None of the 45 current MDAPs in our review reported using any other transaction authority instruments in connection with Section 864 of the NDAA for Fiscal Year 2018. Only two of the 6 future MDAPs reported using other transaction agreements. The Army's Precision Strike Missile reported awarding two separate OTs totaling $240.5 million, although the awards occurred prior to enactment of this provision.
- Although our other ongoing work has identified that DOD has begun over 30 middle-tier acquisition programs under the authority granted in DOD guidance implementing Section 804 of the NDAA for Fiscal

Year 2016, MDAPs did not report any plans to use prototypes associated with this authority. For all 51 current and future MDAPs we surveyed, program officials could not identify any middle tier prototypes that, as of February, 2019, had transitioned into their offices for production or fielding. Further, for the 45 current MDAPs we surveyed, officials from 44 of the programs reported that they either did not anticipate receiving any such prototypes in time for critical design review or production decision, or that the question was not applicable. Only one program reported that it did not know whether it would receive such prototypes in the future.

We have ongoing work to assess DOD's efforts to more broadly implement many of these acquisition reforms. We will continue to assess DOD's progress going forward.

Eight Observations from Our Assessment of Knowledge Attained at Key Decision Points and Related Implications for Testing and Software Development

Based on our analysis of 51 selected weapon acquisition programs, we found that while a few programs implemented elements of knowledge-based acquisition practices, implementation across the entire portfolio remains inconsistent. Numerous acquisition programs, both current and future, have proceeded, or plan to proceed, through key acquisition points without the requisite knowledge called for in best practices. For instance, several programs proceeded through key milestones without attaining the knowledge recommended for the event—such as maturing technologies and conducting a preliminary design review prior to starting system development, or testing a system-level integrated prototype to inform a critical design review. Several programs do not plan to deliver a baseline software capability until after production start, and many others plan to declare an initial operational capability in advance of testing. Actions like these increase the risk of cost growth and schedule delays.

For the second year in a row, we analyzed programs that have progressed through all three knowledge points—development start, critical design review, and a production decision. This year's analysis includes 17 programs for which we have previously collected information for prior assessments. This year our analysis revealed that MDAPs that implemented key knowledge practices saw substantially better cost

performance and less schedule growth than programs that have not implemented those same practices. This analysis emphasizes the importance of knowledge-based acquisition practices and the positive effects they can have on acquisition outcomes.

Current Programs Are Inconsistently Following Knowledge-Based Approaches

1. MDAPs have inconsistently applied key knowledge practices, even newer programs that have more recently progressed through early acquisition events. Few programs held preliminary design reviews in advance of development start decisions or demonstrated critical technologies in a realistic environment.

Table 9 presents key knowledge practices and the percent of current acquisition programs that attained the requisite knowledge for each practice.

Table 9: Major Defense Programs Have Not Consistently Implemented Knowledge-Based Acquisition Practices

Practices associated with the three key knowledge points (KP)	Programs that completed the KP before this assessment period	Programs that completed the KP during this assessment period
KP 1 practices	**38 programs**	**Four programs**
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	◐	○

Practices associated with the three key knowledge points (KP)	Programs that completed the KP before this assessment period	Programs that completed the KP during this assessment period
KP 2 practices	**33 programs**	**Two programs**
Release at least 90 percent of design drawings to manufacturing	○	●
Test a system-level integrated prototype	○	○

Practices associated with the three key knowledge points (KP)	Programs that completed the KP before this assessment period	Programs that completed the KP during this assessment period
KP 3 practices	**15 programs**	**Three programs**

Practices associated with the three key knowledge points (KP)	Programs that completed the KP before this assessment period	Programs that completed the KP during this assessment period
KP 3 practices	**15 programs**	**Three programs**
Demonstrate critical manufacturing processes are in statistical control	○	○
Demonstrate critical processes on a pilot production line	◐	●

Practices associated with the three key knowledge points (KP)	Programs that completed the KP before this assessment period	Programs that completed the KP during this assessment period
Test a production-representative prototype in its intended environment	○	●

Legend:

● Practice implemented in 75 – 100 percent of programs

◐ Practice implemented in 50 – 74 percent of programs

○ Practice implemented in 0 – 49 percent of programs

Source: GAO analysis of Department of Defense data. | GAO-19-336SP

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.

Observation 2: Programs' definitions of critical technologies varied. Most programs did not fully demonstrate mature technologies, and only about half completed system engineering reviews, before starting development.

Establishing a consistent definition of the term "critical technology" is important for acquisition programs so they can correctly identify all critical technology elements. As we have previously reported, not doing so could result in an underrepresentation of the technical risk facing the program.[26] GAO's Technology Readiness Assessment Guide establishes criteria for identifying critical technology elements. [27] It states that a critical technology element is one that is new or novel, and necessary for a system to meet its anticipated operational performance requirements; or

[26]GAO, *Columbia Class Submarine: Immature Technologies Present Risks to Achieving Cost, Schedule, and Performance Goals*, GAO-15-158 (Washington, D.C.: Dec. 21, 2017).

[27]GAO, *GAO Technology Readiness Assessment Guide: Best Practices for Evaluating the Readiness of Technology for Use in Acquisition Programs and Projects--Exposure Draft,* GAO-16-410G (Washington, D.C.: Aug. 11, 2016).

poses a major cost, schedule, or performance risk during design or demonstration.

We observed that while the major acquisition programs in our review define the term "critical technology" differently from one another, these reported definitions frequently included several common elements. For instance, the three most common elements program officials included in their definitions were that

- the system being acquired depends on the technology element to meet requirements,
- the technology is new or novel, and
- the technology poses a major technological risk.

Eighteen of 51 programs included these three elements in their definition of "critical technology."

According to knowledge-based best practices, programs should fully demonstrate critical technologies in a realistic environment and conduct a preliminary design review before starting system development. DOD and commercial technology development cases show the more mature technology is at the start of the program, the more likely the program will succeed in meeting its objectives.[28] Technologies that were included in a product development before they were mature later contributed to cost increases and schedule delays in those products.[29]

Table 10 presents the number of programs that had fully matured technologies when they began system development as well as the number of programs that had technologies approaching maturity at that time. The table presents the information for 42 current MDAPs that began development before or during our assessment period.[30] See appendix VIII for additional details on technology readiness levels.

[28]GAO-16-410G.

[29]Ibid.

[30]Three of the current MDAPs we assessed entered the acquisition cycle post-development start. We therefore excluded these three programs from this analysis.

Table 10: Technology Readiness Levels (TRL) Reported by 42 Current Major Defense Acquisition Programs

	Thirty-eight programs that began development before our assessment period			
	System prototype demonstration in an operational environment (TRL 7)		System/subsystem model or prototype demonstration in a relevant environment (TRL 6)	
	Number of systems	Percentage of systems	Number of systems	Percentage of systems
Met	3	8 percent	24	63 percent
Not met	30	79 percent	9	24 percent
Not applicable or information not available	5	13 percent	5	13 percent

	Four programs that began development during our assessment period			
	System prototype demonstration in an operational environment (TRL 7)		System/subsystem model or prototype demonstration in a relevant environment (TRL 6)	
	Number of systems	Percentage of systems	Number of systems	Percentage of systems
Met	0	0 percent	2	50 percent
Not met	2	50 percent	0	0 percent
Not applicable or information not available	2	50 percent	2	50 percent

Source: GAO analysis of Department of Defense data. | GAO-19-336SP

Note: A technology achieves TRL 7 when it has achieved form, fit, and function, and has been demonstrated in an operational environment. A technology that achieves TRL 6 is close to form, fit, and function, and has been demonstrated in a high-fidelity laboratory environment. Progressing from TRL 6 to TRL 7 is a significant step for a critical technology. While GAO's best practices work has shown that a TRL 7 is the level of technology maturity that constitutes a low risk for starting development, DOD's policy, permits development to start at TRL 6. 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).

Impact of Immature Technologies

In two extreme cases, the Family of Advanced Beyond Line-of-Sight Terminals (FAB-T) and the F-35 Joint Strike Fighter, the programs still had immature critical technologies that, at the start of development, were basically advanced breadboard demonstrators in a laboratory environment, which does not reach the maturity level associated with best practices for starting development. The current cost growth for the FAB-T and F-35 since their first full estimates is 31 percent and 51 percent, respectively. Each program also had significant schedule delays for declaring initial operational capabilities. The FAB-T IOC date slipped 96 months and the F-35 IOC date slipped 62 months.

Source: GAO analysis of Department of Defense data. | GAO 19-336SP

According to knowledge-based practices, DOD policy, and statute, programs should conduct a preliminary design review (PDR) before beginning system development.[31] DOD policy also generally requires programs to complete formal system reviews in advance of beginning development. Further, best practices require programs to constrain their development periods to 6 years or less.[32] These reviews are intended to demonstrate that requirements are well understood and that the systems' functional baselines can satisfy those requirements.

Table 11 identifies the number of programs that held preliminary design reviews, key system reviews, and constrained development phases to 6 years or less. The table presents information for 42 current MDAPs that began development before and during our assessment period.[33]

Table 11: Number of 42 Selected, Current Programs that Met Key Knowledge Practices Prior to Beginning Development

	Thirty-eight programs that began development before our assessment period		
	Held a preliminary design review before starting development	Held system reviews before starting development	Constrain development phase to 6 years or less
Yes	19	16	19
No	17	12	8

[31]The purpose of a PDR is to assess the maturity of the preliminary design, supported by the results of requirements trades, prototyping, and critical technology demonstrations. The PDR establishes the allocated baseline (a definition of the configuration items making up a system, and then how system function and performance requirements are allocated across lower level configuration items) and confirms that the system under review is ready to proceed into detailed design. In detailed design, the program office will develop build-to drawings, software code-to documentation, and other fabrication documentation. By statute, 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)

[32]GAO-18-360SP.

[33]Three of the current MDAPs we assessed entered the acquisition cycle post-development start. We therefore excluded these three programs from this analysis.

	Letter			
Not applicable or information not available		2	10	11

	Four programs that began development during our assessment period		
	Held a preliminary design review before starting development	Held system reviews before starting development	Constrain development phase to 6 years or less
Yes	0	2	2
No	1	0	0
Not applicable or information not available	3	2	2

Source: GAO analysis of Department of Defense data. | GAO-19-336SP

- As in prior years, many programs in the 2018 portfolio began development without conducting a preliminary design review. DOD policy implementing related statute requires that PDR occur in advance of development start, unless the program's milestone decision authority grants a waiver for this requirement. Of the 38 programs that began development before our assessment period, only half conducted a preliminary design review prior to beginning system development.[34]
- Of the four programs that began development during our assessment period, two do not plan to conduct a preliminary design review, and one has yet to identify a date for its preliminary design review. Only one program—the Presidential Aircraft Recapitalization (PAR) — has conducted a PDR, but it occurred three months after beginning development, which is inconsistent with best practices.
- Also, 12 programs did not hold system reviews in advance of starting development, as generally required by DOD policy. Three of those programs had cost growth of greater than 55 percent, while two other programs had modest cost growth of 10 percent or less. Two other programs, the Army's JLTV program and the Air Force's KC-46 program, had cost reductions of 5 percent and 16 percent, respectively.

[34]We did not evaluate why these programs did not hold a preliminary design review in advance of beginning development. In some cases, programs may have received a waiver from their milestone decision authority.

Observation 3. Most programs did not fully demonstrate system design stability prior to conducting critical design reviews.

We found that 35 programs held a knowledge point 2 event (critical design review) either before or during our assessment period. Table 12 shows the number of those that satisfied the two associated key knowledge-based acquisition practices. Only two programs held a critical design review (or, for ships, began construction) during our assessment period.

Table 12: Number of Programs Demonstrating Sufficient Design Knowledge Prior to Knowledge Point 2

	Thirty-three programs that held a critical design review before our assessment period	
	Number of programs that tested an early system-level integrated prototype	**Number of programs that released at least 90 percent of design drawings**
Yes	4	11
No	22	17
Not applicable or information not available	7	5

	Two programs that held a critical design review during our assessment period	
	Number of programs that tested an early system-level integrated prototype	**Number of programs that released at least 90 percent of design drawings**
Yes	0	2
No	1	0
Not applicable or information not available	1	0

Source: GAO analysis of Department of Defense data. | GAO-19-336SP

- Seventeen of the 35 programs had not released 90 percent of their design drawings by the time of the critical design review, and five of those programs still had not released 90 percent of the design drawings by the time low-rate production began. Combined, those five programs experienced almost 27 percent average cost growth above their first full estimates.
- The Navy's CH-53K program did not test a system-level integrated prototype until 45 months after its critical design review. At the same time, the program's acquisition cycle time slipped 51 months and total acquisition costs grew by more than $10 billion—an increase of more than 55 percent. The Joint Precision Approach and Landing System system-level integrated prototype test was 85 months late and,

consequently, the program delayed its initial operational capability declaration by 72 months and total acquisition costs grew by more than 69 percent.

- The one non-ship program that conducted a critical design review during our assessment period, the B-2 Defensive Management System Modernization (DMS-M) program, did not test an early system-level prototype prior to its critical design review, but did so 7 months afterward. The Navy's Fleet Replenishment Oiler (T-AO 205) began lead-ship construction during our assessment period. Both the B-2 DMS-M and T-AO 205 programs delivered 90 percent of their design drawings to manufacturing in advance of their knowledge point 2 events, and the programs experienced cost increases over their first full estimates of only 2.7 percent and 0.5 percent, respectively. Both programs also held system requirements reviews and system functional reviews prior to beginning development.
- Of the six future acquisition programs we assessed, only one, the B-52 Radar Modernization Program, identified a date for testing an early system-level integrated prototype. However, this event is scheduled more than two years after the program's critical design review.

Observation 4. Only one program we reviewed reported that its manufacturing processes were in statistical control prior to starting production.

Programs that held production decisions during our assessment period demonstrated higher levels of production-related knowledge than programs that started production in advance of our assessment period. In fact, all three programs that began production during our assessment period satisfied the knowledge requirements for two of the key practices associated with production—testing a production-representative prototype in its intended environment and demonstrating critical processes on a pilot production line. However, none of those three programs demonstrated the knowledge associated with a third key production-related practice—demonstrating manufacturing processes are in statistical control.

Table 13 identifies the number of programs that satisfied those three key production-related practices. The table presents the information for programs that both began production before our assessment period and those that began production during our assessment period.

Table 13: Program Completion of Key Production-Related Knowledge Practices

	Fifteen programs that began production before our assessment period		
	Test a production-representative prototype in its intended environment	Demonstrate critical processes on a pilot production line	Demonstrate critical manufacturing processes are in statistical control
Yes	7	8	1
No	8	5	13
Not applicable	0	2	1

	Three programs that began production during our assessment period		
	Test a production-representative prototype in its intended environment	Demonstrate critical processes on a pilot production line	Demonstrate critical manufacturing processes are in statistical control
Yes	3	3	0
No	0	0	3
Not applicable	0	0	0

Source: GAO analysis of Department of Defense data. | GAO-19-336SP

Production Knowledge

Of the 15 programs that began production in advance of our assessment period, only one, the Infrared Search and Track, reported compliance with all three production-related knowledge practices contained in table 13. This program also satisfied most, but not all, other knowledge practices throughout its acquisition cycle and experienced virtually no cost changes since its first full estimate.

The Common Infrared Countermeasure, Joint Air to Ground Missile, and the Amphibious Combat Vehicle all began production during our assessment period. Each program satisfied two of the three production-related knowledge practices noted above. These programs also completed most, but not all, of the knowledge practices throughout their lifecycles. The Amphibious Combat Vehicle reported a cost reduction from its first full estimate, while the Joint Air to Ground Missile and the Common Infrared Countermeasure reported modest cost growth since first full estimate of 2.3 percent and 0.1 percent, respectively.

Source: GAO analysis of Department of Defense data. | GAO 19-336SP

Observation 5. Future programs provided mixed signals on their planned implementation of knowledge-based acquisition practices.

The six future programs we surveyed reported that they plan to incorporate some, but not all, of selected knowledge-based acquisition practices associated with development start. A few of these future programs, which remain in their early planning stages, have yet to establish dates for events that serve as key indicators for compliance. Table 14 presents the number of future MDAPs that plan to meet three key knowledge practices associated with beginning system development.

Table 14: Planned Implementation of Selected Knowledge-Based Acquisition Practices at Development Start among Six Future Major Defense Acquisition Programs

	Plan to demonstrate all critical technologies in a realistic environment	Plan to complete all system engineering reviews	Plan for a development phase of less than six years
Yes	0	2	2
No	0	0	0
To be determined	3	1	1
Information not available	3	0	0
Not applicable	0	2	2
Not applicable—ship	0	1	1

Source: GAO analysis of Department of Defense data. | GAO-19-336SP

- Of the six future acquisition programs we surveyed, three have identified specific critical technologies. Our prior work has shown that programs beginning development with immature technologies run a greater risk of cost growth and schedule delays than programs that satisfy the knowledge practices.
- Of the three programs that identified critical technologies, the Air Force's Weather System Follow-on program has the nearest planned system development start date (March 2019). The program has identified eight critical technologies, three of which the program reported as being equivalent to a high-fidelity breadboard demonstration in a laboratory environment, which does not reach the maturity level associated with best practices for starting development.
- Four of the six plan to complete PDR prior to starting development. However, other schedule dates were either not yet available or not applicable, as is the case with Weather System Follow-on, which will not have a production decision.

Observation 6. Certain knowledge-based acquisition practices correspond with better program outcomes.

For the second consecutive year, we conducted an exploratory statistical correlation analysis to determine whether a statistically significant link exists between non-ship programs' cost and schedule performance and their implementation of knowledge-based acquisition practices. We found that, generally, programs that complete certain knowledge practices have better cost and schedule outcomes than programs that do not implement those practices.

This year, we analyzed 17 programs—an increase of two programs as compared to our 2018 analysis—that have completed system development, held a critical design review, and started production (i.e., completed knowledge points 1 through 3).[35] We observed that MDAPs that completed preliminary design review before system development start had an estimated cost savings of 0.5 percent compared to an estimated 65.6 percent cost increase for MDAPs that did not. Further, we observed that this best practice is also associated with shorter schedules to deliver capabilities to the warfighter. Namely, our analysis found a 33.5 percent increase in schedule when programs implement this practice as compared to an 80.5 percent increase when programs do not implement it.

Programs with technologies that were at least approaching maturity also realized, on average, improved cost and schedule performance. Programs implementing this practice realized an average cost reduction of 5.4 percent, while those not implementing the practice had cost growth of 24.0 percent. Programs implementing this practice also realized less growth in acquisition cycle times, 21.5 percent, versus 42.8 percent for those programs that did not implement this practice.

Further, in our 2018 exploratory analysis, we identified a third knowledge practice—delivery of 90 percent of design drawings to manufacturing prior to critical design review—as statistically significant in producing better cost and schedule outcomes in programs.[36] This year's analysis did not revalidate our 2018 analysis, but we plan to continue assessing this measure in future statistical correlation analyses we conduct.

These results support our work and offer continued validation that MDAPs that follow these particular knowledge-based practices achieve lower cost increases and less schedule growth than those programs that do not. Our prior work demonstrates that completion of all of the knowledge-based practices by the time programs reach their knowledge points underpins a

[35]We conducted a means test comparing averages across systems that did and did not complete knowledge-based acquisition practices using a 90 percent confidence interval. See appendix II for additional details.

[36]GAO-18-360SP.

sound business case that positions programs to better meet their cost and schedule goals.[37]

As with last year's annual assessment, the small sample size and the unique characteristics of the 17 MDAPs in the data set limit our analysis. As more programs within our scope enter production, we will be able to offer a more statistically significant analysis of differences between MDAPs that completed or did not complete specific knowledge-based practices.

Observation 7. Programs continue to identify software as a risk area and many do not plan to deliver a baseline software capability prior to production start.

Current weapon systems are dependent upon software for providing warfighter capabilities, as we have reported in prior work.[38] Yet despite this reality, many programs are not tracking software development costs, are underestimating the difficulty of software development efforts, or are not utilizing key software metrics.

According to a 2018 Defense Science Board report, "software is a crucial and growing part of weapons systems and the national security mission."[39] Software is increasingly driving the amount and types of capability that weapon systems provide to the warfighter, and software is an item that often represents considerable risk for weapons acquisition programs. In order to develop that software, programs can choose from a number of different approaches, and there is no single approach that is best for every situation. Table 15 presents a few of the approaches that are more frequently utilized among DOD acquisition programs and their corresponding definitions.

[37]In general, a business case is a justification for a proposed project or undertaking. We have reported that a sound business case for successful defense acquisition programs contains key elements, including firm requirements, mature technologies, a knowledge-based acquisition strategy, a realistic cost estimate, and sufficient funding.

[38]GAO, *Weapon Systems Cybersecurity: DOD Just Beginning to Grapple with Scale of Vulnerabilities*, GAO-19-128 (Washington, D.C.: Oct. 9, 2018).

[39]DOD, *Defense Science Board: Design and Acquisition of Software for Defense Systems* (Washington, D.C.: Feb. 14, 2018).

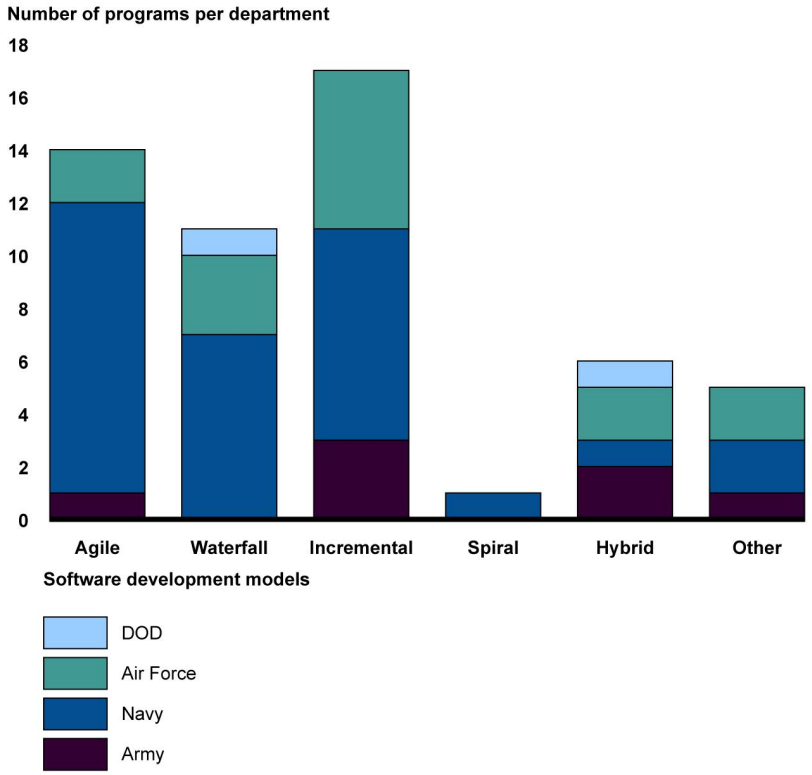
Table 15: Software Development Models Employed by 51 Selected Current and Future Major Defense Acquisition Programs

Software development life cycle model	Description
Waterfall	This model relies on strict phases, and each phase needs to be completed before going to the next phase. The phases include requirements definition, design, execution, testing, and release. Each phase relies on information from the previous phase. This model is a linear sequential flow in which progress is seen as flowing steadily downwards (like a waterfall) through the phases of software implementation.
Incremental	This model sets high level requirements early in the effort, and functionality is delivered in stages. Multiple increments delivery part of the overall required program capability. Several builds and deployments are typically necessary to satisfy approved requirements.
Spiral	This model takes ideas from the incremental model and its repetition but also combines the structured and systematic development of the waterfall model with a heavy emphasis on risk analysis. The project passes through four phases (identification, design, build, evaluation and risk analysis) over and over in a “spiral” until completed, allowing for multiple rounds of refinement.
Agile	This model breaks a product into components where on each cycle or iteration, a working model of a component is delivered. The model produces ongoing releases, each time adding small changes to the previous release. During each iteration, as the product is being built, it is also tested to ensure that at the end of the iteration the product is shippable. The Agile model emphasizes collaboration, as the customers, developers, and testers work together throughout the project.
Hybrid	This approach is a combination of two or more different methodologies or systems to create a new model.

Source: GAO analysis of Department of Defense and software industry documentation. | GAO-19-336SP

Programs we surveyed reported using a variety of these approaches, and many programs use multiple software development approaches when a single approach is not the best option for the capabilities being developed. Figure 17 shows the various software development models that selected current and future MDAPs have employed.

Figure 17: Distribution of Software Development Models among 51 Selected Current and Future Major Defense Acquisition Programs



Source: GAO analysis of Department of Defense data. | GAO-19-336SP

Note: "Other" category represents any software development approach that programs identified to us that does not fall into one of the five DOD-identified models. In addition, some programs reported using multiple approaches. As a result, the columns in the figure do not sum to 51.

- Among the 51 programs we surveyed, the most frequently utilized software development model was the incremental approach, with 17 programs reporting its use. The Air Force's Combat Rescue Helicopter is an example of a program using multiple software models for various subsystems, and one of those models is the incremental approach. The spiral model is the least utilized. Only one program, the Navy's DDG 1000, reported using this approach.
- Some program officials reported using "other" software development methods, for a variety of reasons. The Navy's Virginia Class Submarine (SSN 774) initially used a waterfall-like approach to deliver required software. However, program officials reported that the SSN 774 program no longer employs that approach because software deliveries are complete and the Navy is modifying existing software to accommodate revised ship characteristics.

- Eleven Navy programs reported utilizing the agile software development method, the most among any military department. Only two Air Force programs and one Army program reported using the agile software method.

Table 16 identifies the number of current major programs we surveyed that identified software as a risk at any point during the program's history, as well as the number of programs that satisfied key software-related practices we identified in prior work.[40]

Table 16: Software Risk Identification and Development Practices among 45 Selected Current Major Defense Acquisition Programs

	Software identified as a risk area	Baseline capability completed before production	Baseline capability completed before initial operational capability	Software development costs tracked
Yes	33	16	27	15
No	11	15	4	30
Do Not Know	1	0	0	0
Information Not Available	0	14	14	0

Source: GAO analysis of Department of Defense data. | GAO-19-336SP

- Programs cited three main reasons why they identified software as a risk area:
  - completing the software effort in order to conduct developmental testing successfully,
  - changes for cybersecurity needs leading to additional software development efforts, and
  - completing the originally planned software development effort has proven more difficult than expected.

- Software development has similar phases to that of hardware and—in the case of new systems—occurs in parallel with hardware development until software and hardware components are integrated. According to DOD policy, major contracts and subcontracts for contractors developing or producing software elements for MDAPs are subject to software resource data reporting requirements if the

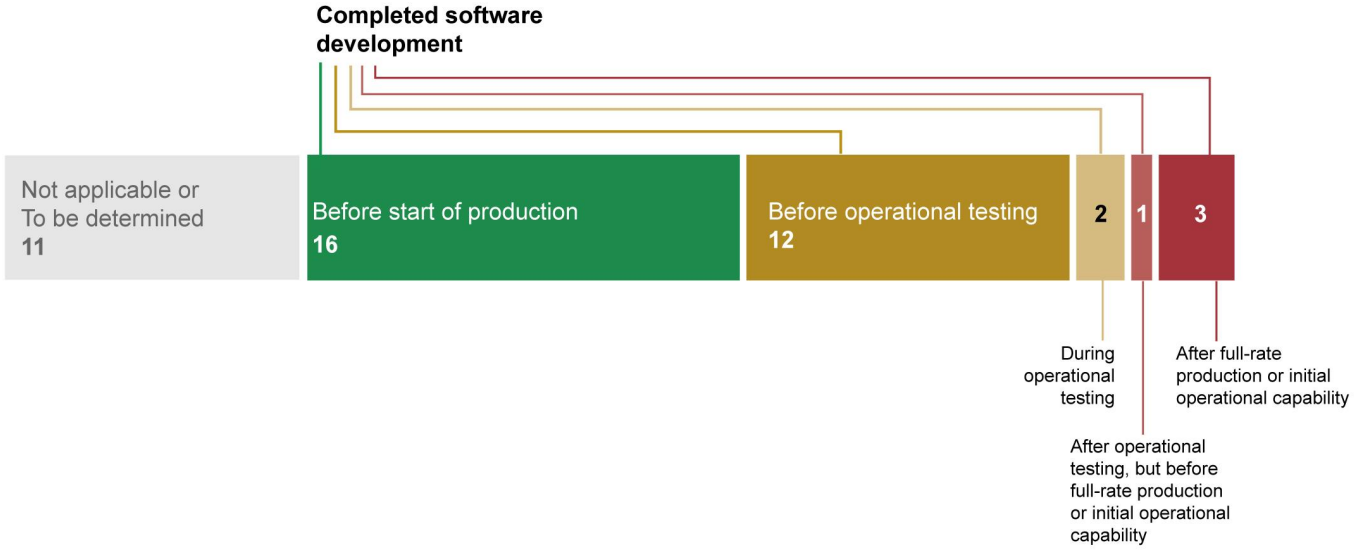
[40]GAO, *Defense Acquisitions: Stronger Management Practices Are Needed to Improve DOD's Software-Intensive Weapon Acquisitions*, GAO-04-393 (Washington, D.C.: Mar. 1, 2004).

software effort is projected to be greater than $20 million.[41] However, when programs do not track the cost of software development separately from the overall development effort, DOD's ability to impose the reporting requirement is constrained.

- We have previously found that 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.[42]

Figure 18 shows the points in the acquisition process when the 45 current MDAPs we surveyed completed, or plan to complete, software development.

Figure 18: Plans for Completing Software Development among 45 Selected Current Major Defense Acquisition Programs



Source: GAO analysis of Department of Defense data. | GAO-19-336SP

[41]Specifically, all major contracts and subcontracts, regardless of contract type, for contractors developing or producing software elements within current and future MDAPs, as well as other certain acquisitions, such as those of certain automated information systems, for any software development element with a projected software effort greater than $20 million (then-year dollars) are required to complete a Software Resources Data Report. DOD Instruction 5000.02, Operation of the Defense Acquisition System (Jan. 2015) [incorporating change 4 (Aug. 2018)] ("DOD Instruction 5000.02").

[42]GAO-18-360SP.

DOD acquisition policy identifies six acquisition models that serve as examples of defense program structures tailored to the type of product being acquired or to the need for accelerated acquisition.[43] Among other things, these models emphasize software development to varying degrees. The policy directs acquisition programs to use these models as a starting point in structuring a program to acquire a specific product. Table 17 identifies these six models in more detail.

Table 17: Department of Defense's (DOD) Six Acquisition Models and Their Basic Characteristics

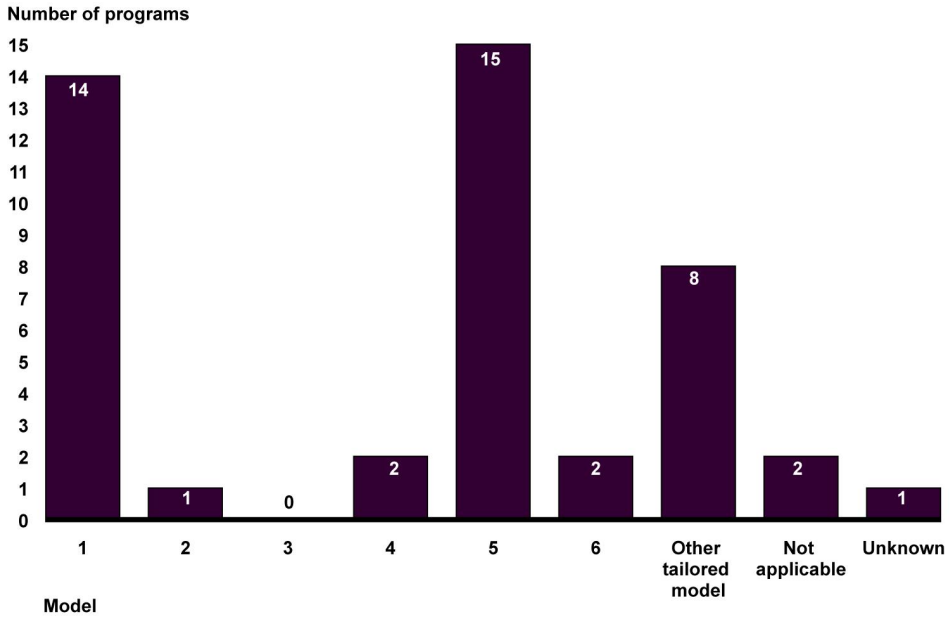
Acquisition Model	Basic Characteristics
Hardware intensive program	This is the classic model for a major weapon program and has existed in some form in all previous editions of DOD's acquisition policy.
Defense unique software intensive program	Uses a series of planned "software builds"—testable, integrated subsets of the overall capability—which together with clearly defined decision criteria, ensure adequate progress is being made before the program commits to subsequent builds.
Incrementally deployed software intensive program	Deploys full software capability in multiple increments as new capability is developed and delivered, nominally in 1- to 2-year cycles.
Accelerated acquisition program	Prioritizes schedule considerations over cost and technical risk considerations by compressing or eliminating phases of the acquisition process and accepting the potential for inefficiencies in order to achieve a deployed capability on a compressed schedule.
Hybrid program A (hardware dominant)	Combines a basic structure hardware development program with a simultaneous, software intensive development effort. Design, fabrication, and testing of physical hardware prototypes may determine the program's overall schedule, decision points, and milestones, but software development will often dictate the pace of program execution and must be tightly integrated and coordinated with hardware development decision points.
Hybrid program B (software dominant)	Centers on a software intensive product development that can include a mix of incrementally deployed software products or releases that include intermediate software builds.

Source: GAO analysis of DOD Instruction 5000.02.| GAO-19-336SP

We asked each program we surveyed to identify the specific model that was most applicable to their program. Figure 19 identifies the distribution of development models among 45 major defense programs.

[43]DOD Instruction 5000.02.

Figure 19: Plans for Utilizing System Development Models among 45 Current Major Defense Acquisition Programs



Model 1: Hardware intensive program
Model 2: Defense unique software intensive program
Model 3: Incrementally deployed software intensive program
Model 4: Accelerated acquisition program
Model 5: Hybrid program A (hardware dominant)
Model 6: Hybrid program B (software dominant)

Source: GAO analysis of Department of Defense data. | GAO-19-336SP

We compared the acquisition models and software development plans that programs reported and observed the following:

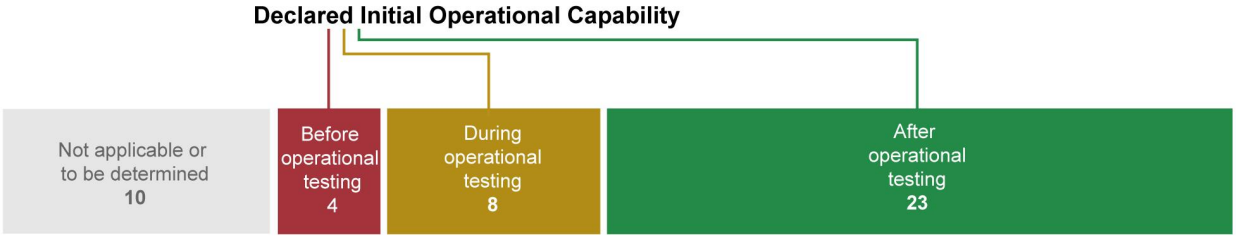
- Of the 15 programs that identified Hybrid Program A (hardware dependent) as their model, 13 reported to us that they had identified software as a risk area for the program. Further, nine of these 15 programs tracked the cost associated with their software development efforts, while six of those 15 programs reported that a baseline software capability would be available in time for the start of production.
- Of the 14 programs that identified Hardware Intensive Program as their model, half the programs either reported that they did not know or do not track the estimated total acquisition costs specifically for software. At the same time, six of these programs reported software as a risk area, and only four reported that a baseline software

capability would be ready for a production decision.

Observation 8. Many programs we surveyed declared, or plan to declare, initial operational capability without conducting 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. However, each individual program declares its initial operational capability date, and programs do not apply consistent standards when determining that date. 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. We have observed programs declaring initial operational capability on the basis of full, partial, or no initial operational test and evaluation. 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. Figure 20 details our analysis of the relationship between initial operational capability and initial operational test and evaluation in 45 current MDAPs.

Figure 20: Plans for Declaring Initial Operational Capability among 45 Selected Current Major Defense Acquisition Programs



Source: GAO analysis of Department of Defense data. | GAO-19-336SP