LEADING PRACTICES

Agency Acquisition Policies Could Better Implement Key Product Development Principles

Accessible Version

GAO Highlights

LEADING PRACTICES

Agency Acquisition Policies Could Better Implement Key Product Development Principles

Why This Study Matters

Each year, the Departments of Defense (DOD) and Homeland Security (DHS) and the National Aeronautics and Space Administration (NASA) together invest hundreds of billions of dollars to buy stealth jets, cutters and ships, and lunar rovers, among other things, all with complex software. However, GAO's annual reviews of these agencies' major acquisitions find they often take longer and spend more money than planned to deliver capabilities to users.

What GAO Recommends

GAO is making nine recommendations to DOD, DHS, and NASA to update acquisition policies to fully implement key principles of product development. All three agencies concurred with our recommendations.

Key Takeaways

that satisfy their customers' needs, and to deliver them to market on time and within planned costs. The 13 leading companies GAO interviewed perform similar activities when developing new products, such as iterative design in hardware and software development. These activities in the development process align with the four key principles that help project teams deliver innovative products to market quickly and efficiently (see figure). GAO found that the department-wide acquisition policies of DOD, DHS, and NASA implement some key product development principles. But, they have yet to fully implement others. This gap limits agencies from ensuring a consistent approach to developing and delivering products with speed and efficiency.
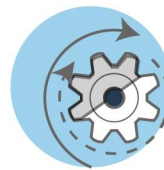
Leading Companies Use Four Key Principles for Product Development

Principle 1
Attain a sound business case that is informed by research along with collaboration with customers

Principle 2
Use an iterative design approach that results in minimum marketable products

Principle 3
Prioritize schedule by off-ramping capabilities when necessary

Principle 4
Collect customer feedback to inform improvements to the minimum marketable product

Source: GAO summary of company information. | GAO-22-104513

Text of Leading Companies Use Four Key Principles for Product Development

- Principle 1: Attain a sound business case that is informed by research along with collaboration with customers
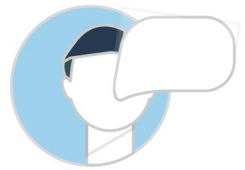
- Principle 2: Use an iterative design approach that results in minimum marketable products

- Principle 3: Prioritize schedule by off-ramping capabilities when necessary

- Principle 4: Collect customer feedback to inform improvements to the minimum marketable product

Source: GAO summary of company information. | GAO-22-104513

For example, leading companies focus on designing a minimum marketable product—one with the minimum capabilities needed for customers to recognize value. Leading companies also prioritize a project's schedule: they release the features most critical to the customer and will off-ramp non-critical product features—an industry term for removing them from the current release—as necessary, in order to maintain schedule. Leading companies have mechanisms to solicit and implement feedback from customers early and often throughout

United States Government Accountability Office

development to ensure the product is relevant to customer needs, among other things.

Primary DOD, DHS, and NASA acquisition policies incorporate many aspects of the four key principles, to varying degrees. However, agencies miss opportunities for positive outcomes by not addressing some sub-principles in their policies.

- DOD's policies do not require all programs to consider off-ramping non-critical capabilities in order to achieve schedule, hindering programs' best chance of maintaining time frames.

- DHS's policies do not require all programs to utilize modern design tools during hardware and software development, limiting consistent opportunities for programs to successfully improve revisions to the design.

- NASA's policies do not include mechanisms for programs to obtain and utilize product feedback from stakeholders or end users—such as astronauts using spacecraft or the science community benefiting from NASA projects—in order to identify challenges or new features to include in subsequent projects.

GAO previously found that other factors beyond policies can affect agency outcomes, including structural differences between government and private industry. However, GAO's prior work also demonstrates that key principles from private industry can be thoughtfully applied to government acquisition to improve outcomes, even with the different cultures and incentives.

How GAO Did This Study

This report examines principles that guide leading companies' product development efforts and the extent to which primary, department-wide DOD, DHS, and NASA acquisition policies reflect the companies' key principles and result in similar outcomes. GAO identified the 13 leading product development companies based on rankings in well-recognized lists; interviewed company representatives; analyzed department-wide acquisition policies from DOD, DHS, and NASA; and interviewed agency officials. The report is the first product in a planned body of work. In future work, GAO will explore how government agencies can apply some of the key principles outlined in this report.

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Abbreviations

AAF	Adaptive Acquisition Framework
ADE	acquisition decision events
AI	Artificial Intelligence
DevOps	Development and Operations
DevSecOps	Development, Security, and Operations
DHS	Department of Homeland Security
DOD	Department of Defense
DODI	Department of Defense Instruction
FAQ	frequently asked questions
IT	information technology
JCIDS	Joint Capabilities Integration and Development System
KDP	key decision point
MDAP	Major Defense Acquisition Program
MOSA	Modular Open Systems Approach
MCVA	minimum viable capability release
MTA	middle-tier of acquisition
MVP	minimum viable product
NDAA	National Defense Authorization Act
NASA	National Aeronautics and Space Administration
NPR	NASA procedural requirement
USD(A&S)	Under Secretary of Defense for Acquisition and Sustainment

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March 10, 2022

Congressional Addressees

Each year, the Department of Defense (DOD), the Department of Homeland Security (DHS), and the National Aeronautics and Space Administration (NASA) together invest hundreds of billions of dollars to buy stealth jets, cutters and ships, and lunar rovers, among other things, all with complex software. Over the last 2 decades, all three agencies have evolved their approaches to these critical acquisitions. For example, new threat environments have been an impetus for speed in delivering weapon and homeland security systems as fast as possible. Given the amount of federal funds spent and the critical missions these agencies support, agencies have consistently underscored the importance of acquisition programs achieving efficiencies and effectiveness, and Congress has passed legislation in this area. We have also addressed the significance of programs achieving these efforts. Specifically, DOD weapon systems acquisition and NASA's acquisition management have been on our High-Risk List since 1990, and we have similarly highlighted DHS management issues, including acquisition management, in high-risk updates since 2003.[1]

For more than 20 years, we have also made numerous recommendations to DOD, NASA, and DHS about acquisitions, which were aimed at improving outcomes. Agencies and Congress acted on many of these recommendations, including taking steps toward implementing knowledge-based acquisition frameworks, which our prior work found is essential to improving performance.[2] Further, our prior work has demonstrated that leading approaches from the private sector can be thoughtfully applied to government acquisition to improve outcomes, even with the cultural and structural differences that yield different sets of incentives for program managers in these environments. For instance, on the basis of our prior work applying leading practices to the DOD acquisition

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[1]GAO, *High-Risk Series: Dedicated Leadership Needed to Address Limited Progress in Most High-Risk Areas*, GAO-21-119SP (Washington, D.C.: Mar. 2, 2021).

[2]For example, see GAO, *NASA Human Space Exploration: Significant Investments in Future Capabilities Require Strengthened Management Oversight*, GAO-21-105 (Washington, D.C.: Dec. 15, 2020); *Department of Homeland Security: Continued Leadership Is Critical to Addressing a Range of Management Challenges*, GAO-19-544T (Washington, D.C.: May 1, 2019); *Navy Shipbuilding: Past Performance Provides Valuable Lessons for Future Investments*, GAO-18-238SP (Washington, D.C.: June 6, 2018); and *Homeland Security: DHS Requires More Disciplined Investment Management to Help Meet Mission Needs*, GAO-12-833 (Washington, D.C.: Sept. 18, 2012).

environment, we identified billions of dollars in cost avoidance savings.[3] These savings resulted from key policy changes DOD implemented and, in some cases, Congress legislated to make greater use of the acquisition leading practices we had long recommended.[4] For a list and description of our best practices reports, see appendix I. In addition, a list of related GAO products is included at the end of the report.

Nonetheless, our annual assessments of major acquisition programs at each agency continue to find that programs often take significantly longer, cost more than initially estimated, and in some cases, deliver final products to end users with less capability than anticipated. For example:

- Our most recent annual assessment of DOD weapon programs in June 2021 found that many of DOD's costliest weapon programs continued to fall short of cost, schedule, or performance goals.[5]

- In January 2021, we found in our annual assessment of DHS major acquisitions that nearly half of the programs we assessed failed to meet a cost or schedule goal at some point in fiscal year 2020.[6]

- We similarly found in our May 2021 annual assessment of NASA's portfolio of major projects that, for the fifth year in a row, NASA's portfolio of major projects in the development stage of the acquisition process continued to experience cost increases and schedule delays.[7]

Leading companies would not be able to sustain such outcomes without potentially going out of business. As we previously reported, this dynamic correspondingly drives them to undertake a disciplined approach to product development—one that is instructive to government acquisition, despite the differences between government and

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[3]For example, we identified $136.1 billion in costs avoided after DOD took positive steps by adopting a framework for applying best practices and the Weapon Systems Acquisition Reform Act of 2009 codified many of our related recommendations. Pub. L. No. 111-23, 123 Stat. 1704 (2009). See GAO, *Performance and Accountability Report: Fiscal Year 2019*, GAO-20-1SP (Washington, D.C.: Nov. 19, 2019); and *Performance and Accountability Report: Fiscal Year 2017*, GAO-18-2SP (Washington, D.C.: Nov. 15, 2017).

[4]Weapon Systems Acquisition Reform Act of 2009, Pub. L. No. 111-23, 123 Stat. 1704 (2009).

[5]GAO, *Weapon Systems Annual Assessment: Updated Oversight Approach Needed*, GAO-21-222 (Washington, D.C.: June 8, 2021).

[6]GAO, *DHS Annual Assessment: Most Acquisition Programs are Meeting Goals but Data Provided to Congress Lacks Context Needed for Effective Oversight*, GAO-21-175 (Washington, D.C.: Jan. 19, 2021).

[7]GAO, *NASA: Assessments of Major Projects*, GAO-21-306 (Washington, D.C.: May 20, 2021).

marketplace environments.[8] Throughout an individual product's development, leading companies often confront difficult trade-off decisions, such as options about design requirements, technical solutions, and where and when to launch a promised solution. These decisions are largely informed by the incentive to be first to market within a globalized marketplace and win enduring customer support.

We prepared this report to address principles contributing to acquisition outcomes within DOD, DHS, and NASA. It is the first product in a planned body of work. We performed our work under the statutory authority of the Comptroller General to conduct evaluations on GAO's initiative. In this report, we examined (1) how selected leading companies structure and organize product development activities, and (2) the extent to which DOD, DHS, and NASA department-wide and primary policies for major acquisitions incorporate key principles that leading companies rely on for successful product development. We identified 13 leading product development companies based on rankings in well-recognized lists; interviewed company representatives and analyzed available company documentation; assessed department-wide acquisition policies from DOD, DHS, and NASA that are applicable to different types of acquisition programs; and interviewed agency officials. Table 1 provides a description of the companies included in our review.

Table 1: Company Industries and Product Types

Company	Primary industry	Product description
Amazon.com	Internet and direct marketing retail	Electronic services that include retail and cloud-computing, as well as consumer electronics, such as Kindle Fire tablets, Fire TV, and Amazon Echo
Carnival Corporation	Cruise line	Commercial ship buyer and operator
Derecktor	Construction	Custom sailing and motor yachts, ferries, and workboats
GE Renewable Energy	Industrial	Onshore and offshore wind platforms, hydropower services, high voltage equipment
Gulfstream Aerospace Corporation	Aerospace and defense	Business-jet aircraft for customers in the U.S. and internationally
IBM	Information Technology	Application software, cloud computing, cybersecurity, information technology infrastructure, and artificial intelligence, among others

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[8]For example, see 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); *Best Practices: Better Support of Weapon System Program Managers Needed to Improve Outcomes*, GAO-06-110 (Washington, D.C.: Nov. 30, 2005); *Best Practices: Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes*, GAO-02-701 (Washington, D.C.: July 15, 2002); and *Best Practices: Better Matching of Needs and Resources Will Lead to Better Weapon System Outcomes*, GAO-01-288 (Washington, D.C.: Mar. 8, 2001).

Company	Primary industry	Product description
Kiewit Corporation	Construction and engineering	Engineering and construction projects for transportation; oil, gas, and chemical; power; building; water/wastewater; industrial; and mining
Merck	Pharmaceuticals	Medicines and vaccines for the prevention, treatment, and control of disease
Planet	Aerospace and data analytics	Satellite data and analytics
Qualcomm	Semiconductors	Integrated circuits and system software for use in wireless voice and data communications, among other things
Siemens	Industrial	Electrical components and equipment, services and products for oil and gas and power generation
SpaceX	Aerospace and defense	Rockets and spacecraft for satellites, cargo, exploration, and other things
Virgin Orbit	Aerospace and defense	Satellite development and launching services

Source: GAO analysis of company information. | GAO-22-104513

Appendix II provides additional information on our objectives, scope, and methodology.

We plan to undertake subsequent work to further focus on identifying specific approaches and metrics that companies employ when applying key principles and understanding to what extent agencies could benefit from incorporating aspects of those practices into their acquisition policies, processes, and programs.

We conducted this performance audit from August 2020 to March 2022 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, NASA, and DHS each have in place policies that guide their major acquisitions. The following sections summarize these policies and our recent findings on program performance.

DOD Acquisition Policy

DOD Acquisition Policy and Recent Program Performance

Table 2 describes the department-wide policies that govern the defense acquisition system.

Table 2: Department of Defense Department-wide Acquisition Policies

Department of Defense policy	Description
Department of Defense Directive 5000.01	Establishes policy and assigns responsibilities for managing all acquisition programs, including life-cycle management, design, and test and evaluation, among other things.
Department of Defense Instruction 5000.02	Establishes the groundwork for the operation of the Adaptive Acquisition Framework.

Source: GAO summary of DOD Directive 5000.01, *The Defense Acquisition System* (Sept. 9, 2020); DOD Instruction 5000.02, *Operation of the Adaptive Acquisition Framework* (Jan. 23, 2020). | GAO-22-104513

Among other things, DOD Directive 5000.01 emphasizes speed in delivering capability. For example, the directive states that the acquisition system will be designed to acquire products and services that satisfy user needs with measurable and timely improvements to mission capability. To achieve these goals, in January 2020, DOD established an Adaptive Acquisition Framework (AAF). The AAF is comprised of six acquisition pathways, each tailored for the characteristics and risk profile of the capability being acquired. Programs, with approval of the decision authority or the milestone decision authority, may leverage a combination of acquisition pathways to provide value not otherwise available through use of a single pathway.[9] Decision-making authority for many programs has shifted from the Office of the Secretary of Defense to the military departments, although the Under Secretary of Defense of Acquisition and Sustainment

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[9]According to DOD Instruction 5000.02, the milestone decision authority is the program decision authority and specifies the decision points and procedures for assigned programs. Milestone decision authorities for Major Defense Acquisition Programs and major systems will approve, as appropriate, the acquisition strategy at all major decision points.

(USD(A&S)) serves as the milestone decision authority for certain major defense acquisition programs.[10] USD(A&S) is also responsible for establishing policies on and supervising the performance of all matters relating to acquisition, including system design, development, and production; and procurement of goods and services and sustainment (including logistics, maintenance, and materiel readiness).

From December 2019 to October 2020, DOD issued policy documents to address each of the six acquisition pathways and issued additional functional policy documents, in areas such as engineering and test and evaluation, along with subsequent updates to certain policies. Under the AAF, capabilities may be developed and fielded using a single pathway or multiple pathways. Figure 1 shows the AAF and corresponding policy specific to each pathway.

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[10]Section 825 of the NDAA for Fiscal Year 2016 required that the service acquisition executive of the military department concerned be designated as the milestone decision authority for Major Defense Acquisition Programs that reach milestone A after October 1, 2016, unless the Secretary of Defense designates an alternate milestone decision authority under certain circumstances outlined in statute, such as the program being critical to a major interagency requirement or technology development effort.

Figure 1: Department of Defense Programs Can Leverage a Combination of Pathways Governed by Individual Policies in the Adaptive Acquisition Framework
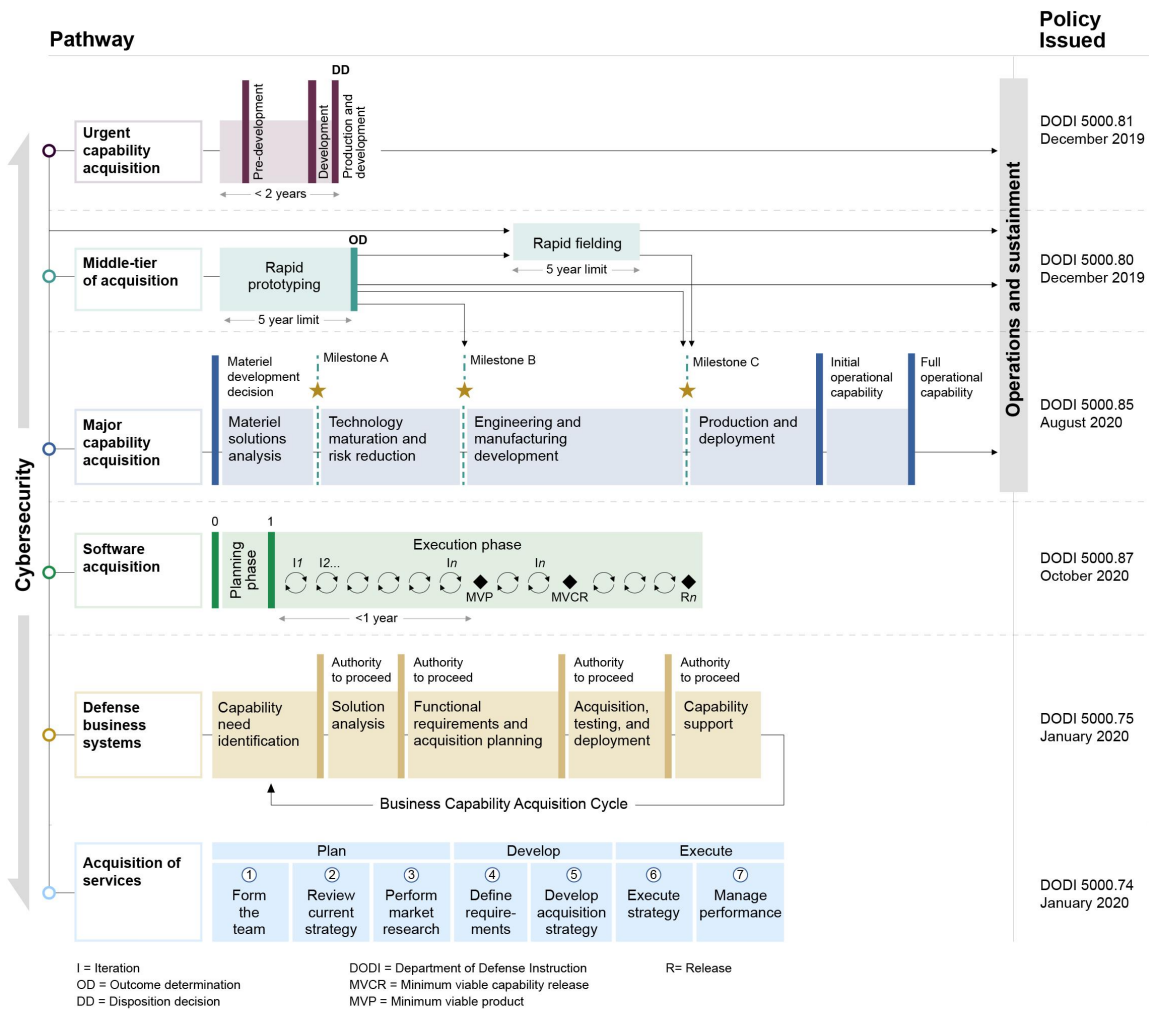
Source: GAO Analysis of Department of Defense data. I GAO-22-104513

In addition to using multiple pathways, a program manager can also undertake multiple distinct efforts using the same pathway, such as two or more rapid prototyping efforts using the middle-tier acquisition (MTA) pathway or two or more software efforts using the software acquisition pathway.

Our Recent Assessments of DOD Acquisition Program Performance

We found in June 2021 that DOD planned to spend at least $1.8 trillion for its costliest weapon programs.[11] Within this portfolio, we found that DOD continued to expand its MTA programs and expected to spend at least $30.5 billion on current efforts. We also found that DOD made efforts to improve portions of its acquisition processes related to its software development and cybersecurity needs, including updating its instructions and providing guidance on Agile software development practices.

For example, the department established the software acquisition pathway in response to recommendations made by the Defense Science Board in February 2018, which advised DOD to adopt continuous iterative development and empower programs to immediately adopt a modern approach to software development. The software acquisition pathway instruction also addresses recommendations we made in 2019 that DOD ensure its software development guidance provides specific, required direction on timing, frequency, and documentation of user involvement and feedback.[12] Our June 2021 assessment found that the number of programs that reported using modern software development approaches—such as Agile, iterative development, and Development and Operations (DevOps) or Development, Security, and Operations (DevSecOps)—increased slightly from our prior 2020 assessment.

However, we also found that quantity changes and other factors such as schedule delays due to performance deficiencies, test delays, and other factors increased costs for specific capabilities or components. Further, we found that changes in production and delivery schedules contributed to 1-year cost growth, and that 16 major defense acquisition programs showed 1-year schedule delays.

While the AAF is relatively new, our annual assessment also found that many programs have planned acquisition approaches that, unless properly managed and overseen, could result in cost and schedule challenges similar to those we reported on for nearly the past 2 decades.[13] Our past work on knowledge-based acquisition practices for major

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[11]GAO, *Weapon Systems Annual Assessment: Updated Program Oversight Approach Needed*, GAO-21-222 (Washington, D.C.: June 8, 2021).

[12]GAO, *DOD Space Acquisitions: Including Users Early and Often in Software Development Could Benefit Programs*, GAO-19-136 (Washington, D.C.: Mar. 18, 2019).

[13]GAO-21-222.

defense acquisition programs suggests that gaining appropriate knowledge related to technology development, design, and production would help MTA efforts achieve positive outcomes. Specifically, we found that gaining this knowledge would help ensure programs using the MTA pathway would be well positioned to field eventual planned capabilities and meet warfighter requirements, including timely delivery of the eventual capability.[14] However, we found in our 2021 annual assessment that MTA programs continue to move forward without having key business case documentation, such as an approved acquisition strategy, approved requirements, formal assessments of technology and schedule risk, or a cost estimate based on independent assessment.

In our most recent High-Risk report, in March 2021, we found that while DOD is implementing significant changes in an effort to improve weapon system outcomes, considerable work remains to strengthen DOD's ability to quickly deliver capabilities to the warfighter.[15]

DHS Acquisition Policy

DHS Acquisition Policy and Recent Program Performance

Table 3 describes the department-wide policies that govern DHS's major acquisitions. Figure 2 reflects the current acquisition life cycle in DHS acquisition management policy.

Table 3: Department of Homeland Security Department-wide Acquisition Policies

Department of Homeland Security (DHS) policy	Description
Acquisition Management Directive 102-01	Provides the overall policy and structure for acquisition management and establishes the Department's Acquisition Lifecycle Framework, Acquisition Review Process, and Acquisition Review Board, along with additional management procedures and responsibilities augmenting existing policies, regulations, and statutes.
Test and Evaluation Directive 026-06	Establishes policies and requirements and assigns responsibilities for test and evaluation activities throughout the acquisition life cycle.
Joint Requirements Integration and Management System Directive 107-01	Provides the overall policy and structure for the Joint Requirements Integration and Management System.

[14]GAO-20-439.

[15]GAO, *High Risk Series: Dedicated Leadership Needed to Address Limited Progress in Most High-Risk Areas*, GAO-21-119SP (Washington, D.C.: Mar. 2, 2021).

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Figure 2: Acquisition Decision Authorities Review DHS Programs at Key Decision Points
Acquisition phases

Need	Analyze / Select	Obtain	Produce / Deploy / Support
DHS officials identify the need for a new acquisition program.	Program manager reviews alternative approaches to meeting the need, and recommends a best option to the decision authority. Component approves preliminary program baseline at entry to Obtain phase.	Program manager develops, tests, and evaluates the selected option; decision authority approves final acquisition program baseline as programs proceed through acquisition decision events.	DHS pursues production and delivers the new capability to its operators, and maintains the capability until it is retired; post-deployment activities tend to account for up to 70 percent of an acquisition program's life-cycle costs.

Acquisition decision events (ADE)

ADE   ADE   ADE   ADE   ADE

Source: GAO analysis of Department of Homeland Security (DHS) data. | GAO-22-104513

Text of Figure 2: Acquisition Decision Authorities Review DHS Programs at Key Decision Points

Acquisition phases

- Need: DHS officials identify the need for a new acquisition program.

- Analyze / Select: Program manager reviews alternative approaches to meeting the need, and recommends a best option to the decision authority. Component approves preliminary program baseline at entry to Obtain phase.

- Obtain: Program manager develops, tests, and evaluates the selected option; decision authority approves final acquisition program baseline as programs proceed through acquisition decision events.

- Produce / Deploy / Support: DHS pursues production and delivers the new capability to its operators, and maintains the capability until it is retired; post- deployment activities tend to account for up to 70 percent of an acquisition program's life-cycle costs.

Source: GAO analysis of Department of Homeland Security (DHS) data. | GAO-22-104513

Certain other DHS instructions and manuals also outline acquisition management expectations in greater detail. These include:

- Acquisition Management Instruction (DHS Instruction 102-01-001);

- Systems Engineering Life Cycle Instruction (DHS Instruction 102-01-103);

- Agile Methodology for Software Development and Delivery for Information Technology (DHS Instruction 102-01-004);

- Agile Development and Delivery for Information Technology (DHS Instruction Manual 102-01-004-01);

- Test and Evaluation Instruction (DHS Instruction 026-06-001);

- Acquisition Program Management Staffing (DHS Instruction 102-01-006); and

- Manual for the Operation of the Joint Requirements Integration and Management System (DHS Instruction Manual 107-01-001-01).

The Under Secretary for Management is designated as the Chief Acquisition Officer and holds the acquisition decision authority for the department's largest acquisition programs, those with life-cycle cost estimates of $1 billion or greater. The Under Secretary for Management may delegate acquisition decision authority for programs with lower cost estimates to Component Acquisition Executives—typically the most senior acquisition management officials within each of DHS's components.[16]

Our Recent Assessments of DHS Acquisition Program Performance

We plan to report in our upcoming 2022 annual assessment that DHS plans to spend over $5 billion on its portfolio of major acquisition programs in fiscal year 2022 to execute its critical missions. Ultimately, the department plans to invest more than $240 billion over the life cycle of these programs. We found that 20 of the 23 programs we assessed with department-approved baselines were meeting their most recent cost and schedule baseline goals. However, this metric obscures that several of these programs, including nine over the past 2 fiscal years, had exceeded their original cost and schedule baselines and subsequently elected to set new baselines from which to measure performance. Breaches were due to factors external to the program, such as labor and supply chain issues related to COVID-19, and internal program factors, such as an underestimation of program complexity.

We have also found that, for several years, some DHS programs have been at risk of not meeting end-user needs. End users are the individual or group who will use the acquisition for its intended operational use when deployed. In some cases, we found this risk of not meeting end-user needs was because program requirements did not accurately describe those needs, or they were not achievable given available technologies.[17]

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[16]DHS's components consist of operational components—those that have responsibility for directly achieving one or more of the department's missions or activities—and support components—those that generally provide assistance or guidance to other DHS components or external organizations. For example, the Management Directorate is a support component. Operational components include U.S. Customs and Border Protection, the Transportation Security Administration, and the U.S. Coast Guard.

[17]GAO, *DHS Annual Assessment: Most Acquisition Programs Are Meeting Goals but Data Provided to Congress Lacks Context Needed For Effective Oversight,* GAO-21-175 (Washington, D.C.: Jan. 19, 2021; *DHS Acquisitions: Additional Practices Could Help Components Better Develop Operational Requirements*, GAO-18-550 (Washington, D.C.: Aug. 8, 2018).

In our most recent High-Risk report, we found in March 2021 that DHS has yet to fully address several acquisition management outcomes but has made significant progress in these areas, including enhancements to its acquisition management, resource allocation, and requirements policies that reflect key portfolio management practices.[18]

NASA Acquisition Policy

NASA Acquisition Policy and Recent Program Performance

Table 4 describes the department-wide policies that govern NASA's major acquisitions.

Table 4: National Aeronautics and Space Administration Department-wide Acquisition Policies

National Aeronautics and Space Administration (NASA) policy	Description
NASA Policy Directive 1000.0C	The Governance and Strategic Management Handbook sets forth NASA's governance framework, including principles and structures through which the agency manages mission, roles, and responsibilities; and describes NASA's Strategic Management System—processes by which the agency manages strategy and its implementation through planning, performance, and results.
NASA Policy Directive 1000.5C	Augments NASA policy Directive 1000.0C with the overall policy framework for NASA's strategic acquisition processes.
NASA Policy Directive 1000.3E	Documents NASA's organization, defines terms, and sets forth the standards and requirements for establishing, modifying, and documenting the NASA organizational structure and for assigning organizational responsibilities.
NASA Policy Directive 7120.4E	Provides the statement of policy, principles, and responsibilities for program and project management and system and software engineering disciplines at NASA.
NASA Policy Directive 7120.6A	Provides NASA's policy for managing technical program and project knowledge and making this knowledge accessible across all Centers and Mission Directorates.

Source: GAO summary of National Aeronautics and Space Administration, *NASA Governance and Strategic Management Handbook*, NASA Policy Directive 1000.0C (Jan. 29, 2020); National Aeronautics and Space Administration, *Policy for NASA Acquisition*, NASA Policy Directive 1000.5C (July 13, 2020); National Aeronautics and Space Administration, *The NASA Organization*, NASA Policy Directive 1000.3E (Apr. 14, 2015); National Aeronautics and Space Administration, *NASA Engineering and Program/Project Management Policy*, NASA Policy Directive 7120.4E (June 26, 2017); National Aeronautics and Space Administration, *Knowledge Policy for Programs and Projects*, NASA Policy Directive 7120.6A (Dec. 16, 2019). | GAO-22-104513

In addition, certain other NASA procedural requirements (NPR) outline acquisition management expectations in greater detail. These include:

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[18]GAO-21-119SP.

- NASA Space Flight Program and Project Management Requirements (NPR 7120.5F);

- NASA Systems Engineering Processes and Requirements (NPR 7123.1C);

- NASA Information Technology Program and Project Management Requirements (NPR 7120.7A);

- NASA Software Engineering Requirements (NPR 7150.2C); and

- NASA Space Flight Program and Project Management Handbook (NASA/SP-2014-3705).

The Office of the Chief Engineer is responsible for NASA's program and project management and systems engineering policy and guidance.[19] The life cycle for NASA space flight projects consists of two main phases: (1) formulation, which takes a project from concept to preliminary design, and (2) implementation, which includes building, launching, and operating the system, among other activities. NASA further divides formulation and implementation into phases A through F.

Major projects must get approval from senior NASA officials at key decision points before they can enter each new phase. The NASA Associate Administrator is the decision authority for all programs and for Category 1 projects—those with life-cycle costs that exceed $2 billion, contain significant radioactive material, or are human space flight projects. The Associate Administrator may delegate this authority to the Mission Directorate Associate Administrator for Category 1 projects. For Category 2 and 3 projects, the Decision Authority is the Mission Directorate Associate Administrator. The Mission Directorate Associate Administrator may delegate some Programmatic Authority to appropriate Mission Directorate staff or to NASA Center Directors. Figure 3 depicts NASA's life cycle and key decision points for space flight projects.

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[19]The NASA Chief Information Officer is responsible for technology program and project management requirements.

Figure 3: NASA's Space Flight Programs Progress through Two Main Phases
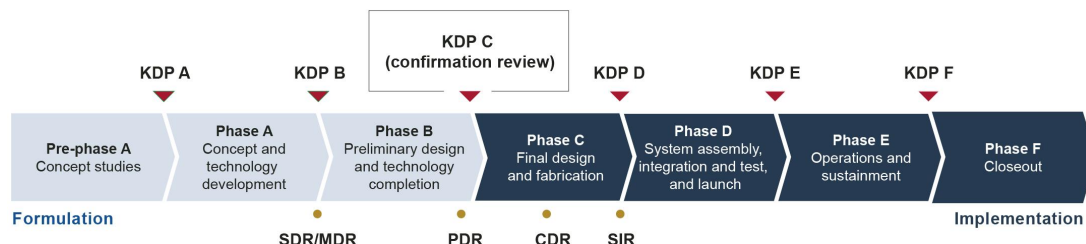
Management decision reviews

▼ KDP = key decision point

Technical reviews

● SDR/MDR = system definition review/mission definition review

● PDR = preliminary design review

● CDR = critical design review

● SIR = system integration review

Source: GAO presentation of National Aeronautics and Space Administration (NASA) information. | GAO-22-104513

Text of Figure 3: NASA's Space Flight Programs Progress through Two Main Phases

- Pre-phase A: Concept studies

- Key Decision Point A

- Phase A: Concept and technology development

- Key Decision Point B

- System definition review / mission definition review

- Phase B: Preliminary design and technology completion

- Key Decision Point C

- Preliminary design review

- Phase C

- Critical design review

- Key decision point D

- System integration review

- Phase D: System assembly, integration and test and launch

- Key Decision Point E

- Phase E: Operations and sustainment

- Key decision point F

- Phase F: Closeout

Our Recent Assessments of NASA Acquisition Program Performance

We found in May 2021 that NASA plans to invest at least $69 billion to develop, build, test, and operate the systems included in its growing portfolio of major projects, which we define as those projects or programs with an estimated life-cycle cost of over $250 million.[20] We found that most projects that held a preliminary design review demonstrated that the project's critical technologies—new or novel technologies needed to meet requirements—were mature. By doing so, the projects demonstrated that the technologies can perform as needed under realistic conditions before committing to use them in the system.

However, NASA's major projects have also historically committed to significant advances in technology without a realistic assessment of the effort and resources required. For example, we found in January 2020 that the James Webb Space Telescope—a large, infrared-optimized space telescope designed to help understand the origin and destiny of the universe—has encountered years of technical and management challenges, contractor performance issues, and low levels of cost reserves. As of May 2021, we found that the program had seen cost growth of 95 percent and schedule growth of 88 months above initial estimates.[21] Our previous work also found that NASA has not always followed leading practices and its own acquisition policies in areas such as estimating costs and schedules and earned value management. Programs have also inconsistently updated project cost and schedule estimates as new risks emerge.[22]

For years we have reported in our High-Risk reports on NASA's persistent cost growth and schedule delays, due in part to reliability of cost and schedule estimating and management weaknesses that have exacerbated the inherent technical and engineering risks faced by NASA's largest projects.[23] In our most recent High-Risk report, we found in March 2021 that NASA's demonstrated progress across its portfolio of major projects

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[20]GAO-21-306.

[21]GAO-21-306.

[22]GAO, *NASA: Assessments of Major Projects*, GAO-20-405 (Washington, D.C.: Apr. 29, 2020).

[23]For example, GAO-21-119SP; *High-Risk Series: Substantial Efforts Needed to Achieve Greater Progress on High-Risk Areas*, GAO-19-157SP (Washington, D.C.: Mar. 6, 2019); *High Risk Series: Progress on Many High-Risk Areas, While Substantial Efforts Needed on Others*, GAO-17-317 (Washington, D.C.: Feb. 15, 2017); *High-Risk Series: Key Actions to Make Progress Addressing High-Risk Issues*, GAO-16-480R (Washington, D.C.: Apr. 25, 2016); *High-Risk Series: An Update*, GAO-15-290 (Washington, D.C.: Feb. 11, 2015).

has been mixed, with continuing setbacks for the largest programs.[24] We noted that NASA should take action to demonstrate sustained improvement in cost and schedule performance for new, large, complex programs entering the portfolio.

Differences between Commercial Product Development and Government Acquisition Environments

Agency policies that implement key principles for product development provide an important tool to assist acquisition programs in delivering capability within the cost and schedule allotted to them. However, other factors also contribute to the outcomes these programs ultimately achieve. As we previously found, government acquisition programs operate in a different environment than leading companies.[25] These differences, both cultural and structural, yield different sets of incentives for the program managers in these environments.

For example, DOD, DHS, and NASA acquisitions involve weapon systems, national security, and basic science and human space exploration, among other things, that benefit the public good. Consequently, the capabilities these programs seek to provide can be more extensive than product development undertaken by leading companies. In addition, we previously noted that the federal budgeting process provides incentives for programs to be funded before sufficient knowledge is available to make key decisions.[26] The leading companies we previously interviewed pointed to their ability to withhold funding in a program until they were able to determine that the business case for a product was sound and worth pursuing. However, government officials often must commit to an acquisition program budget years before the program begins in earnest, thereby restricting a sound understanding of program realities prior to funding it.

Additionally, private companies operate in a different environment than federal agencies when acquiring or developing a new product. Private companies often focus on financial measures like profit margins and return on investment, but federal agencies do not. Further, federal acquisitions are subject to laws and regulations intended to promote transparency and fairness, and to support socioeconomic goals. For example, federal agencies are expected to maximize competition for government contracts and meet small business utilization goals, which can introduce additional dimensions to acquisition at federal agencies. Other differences include:

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[24]GAO-21-119SP.

[25]GAO, *Best Practices: Successful Application to Weapon Acquisitions Requires Changes in DOD's Environment*, GAO/NSIAD-98-56 (Washington, D.C.: Feb. 24, 1998); GAO-04-386SP; GAO-17-499; GAO-16-187T; and GAO-16-84T.

[26]GAO-16-187T; and GAO-16-84T.

- unique external pressures to continue projects within government acquisition programs, such as narrow launch windows or international partnerships and mitigation of safety and mission success risk;

- comparative inflexibility in hiring qualified personnel as needs for a program fluctuate; and

- the large numbers of jobs that depend on federal contracting due to the vast amount of money the federal government spends through contracts.

We have also reported that the leading commercial and defense environments foster different incentives and, therefore, elicit different culture and behaviors from the people managing the programs.[27] The prevailing culture in government acquisition incentivizes starting programs quickly—an approach that often does not comport with finishing quickly, which leading companies prioritize. Correspondingly, government acquisition programs seek to organize around business cases that will help them successfully obtain funding and start. This situation often leads programs to put forward a business case that (1) is premised on delivering exceptional capability, at an optimistic cost, and within an aggressive schedule, and (2) distinguishes itself from other programs competing for the same pool of resources, so as to convince stakeholders, including Congress, that the program warrants funding.

By comparison, leading companies define successful product developments as those that meet customer needs and, subsequently, generate a positive return on investment. Consequently, sound business cases are paramount for leading companies—because the lack of one can preclude a company from obtaining financial returns on its product development investment. As noted, our prior work has found that despite these differences, government agencies can still apply key principles from the private sector to government acquisition to improve outcomes.

Key Concepts in Product Development

Product development includes the process of translating requirements into specific design features, identifying key risks, making design trade-offs based on early tests and systems engineering, then prototyping and ultimately manufacturing the product. For the past several years, we reported on a number of areas related to product development. Selected reports and product development concepts are included below.

- <u>Transition from science and technology to product development.</u> Product development innovations are only as good as the technology development activities that feed into them. Our prior work identified leading practices within this technology development phase. Our findings include (1) the importance of a balance between

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[27]For example, see GAO, *Best Practices: Successful Application to Weapon Acquisitions Requires Changes in DOD's Environment*, GAO/NSIAD-98-56 (Washington, D.C.: Feb. 24, 1998).

breakthrough, disruptive technologies—those considered to be innovative—and moderate, incremental technology enhancements; (2) generating opportunities for the acquisition community to become steadily involved in a technology's development; and (3) creating an environment that attracts companies that do not typically sell or develop products for DOD's use.[28]

- <u>Agile development</u>. Agile development originated as a software philosophy that emphasized early and continuous software delivery, fast feedback cycles, rhythmic delivery pace, the use of collaborative teams, and measuring progress in terms of working software. We previously reported that the most well-known feature of Agile software development is its emphasis on iterative product development and delivery; that is, development of software in iterations that are being continuously evaluated on their functionality, quality, and customer satisfaction.[29] Information obtained during these frequent iterations can effectively assist in measuring progress and allowing developers to respond quickly to feedback from customers, thus reducing technical and programmatic risk. We found that Agile can be a valuable tool for organizations in helping to mitigate schedule and budget risks.[30]

- <u>Minimum viable products.</u> Agile development is often associated with a minimum viable product—the simplest version of a product that can be released and generate positive financial returns. It is followed by a successive next viable product. We reported in September 2020 that a minimally viable product should have enough value that it is still usable, demonstrates future benefit early on to retain customer buy in, and provides a feedback loop to help guide future development.[31]

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[28]For example, see GAO, *DOD Acquisition Reform: Increased Focus on Knowledge Needed to Achieve Intended Performance and Innovation Outcomes*, GAO-21-511T (Washington, D.C.: Apr. 28, 2021); *Defense Science and Technology: Opportunities to Better Integrate Industry Independent Research and Development into DOD Planning*, GAO-20-578 (Washington, D.C.: Sept. 3, 2020); *Military Acquisitions: DOD Is Taking Steps to Address Challenges Faced by Certain Companies*, GAO-17-644 (Washington, D.C.: July 20, 2017); *Defense Science and Technology: Adopting Best Practices Can Improve Innovation Investments and Management*, GAO-17-499 (Washington, D.C.: June 29, 2017).

[29]GAO, *Agile Assessment Guide: Best Practices for Agile Adoption and Implementation*, GAO-20-590G (Washington, D.C.: September 2020).

[30]For example, see GAO-21-222; GAO-20-590G; GAO, *Defense Acquisitions Annual Assessment: Drive to Deliver Capabilities Faster Increases of Program Knowledge and Consistent Data for Oversight*, GAO-20-439 (Washington, D.C.: June 3, 2020); *DOD Space Acquisitions: Including Users Early and Often in Software Development Could Benefit Programs*, GAO-19-136 (Washington, D.C.: Mar. 18, 2019).

[31]GAO-20-590G.

Leading Companies Organize Product Development Activities around Four Key Principles

We found that leading companies adhere to four key principles that permeate each stage of the product development process and enable leading companies to develop new and innovative products successfully (see fig. 4). Specifically, leading companies we reviewed perform similar activities when developing their products (see fig. 5 for an interactive graphic and appendix VI for the non-interactive, printer-friendly version). Within these activities, the four key principles position leading companies to deliver hardware and software products to market with speed, generate returns on their product investment, and satisfy their customers' needs.

Figure 4: Leading Companies Rely on Four Key Principles to Enable Successful Product Development

Principle 1:
Attain a sound business case that is informed by research along with collaboration with customers

Principle 2:
Use an iterative design approach that results in minimum marketable products

Principle 3:
Prioritize schedule by off-ramping capabilities when necessary

Principle 4:
Collect customer feedback to inform improvements to the minimum marketable product
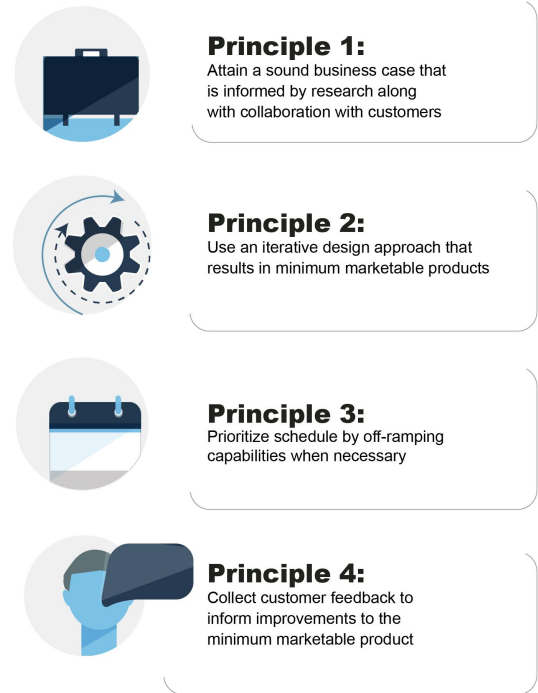
Source: GAO summary of company information | GAO-22-104513

Text of Figure 4: Leading Companies Rely on Four Key Principles to Enable Successful Product Development

- Principle 1: Attain a sound business case that is informed by research along with collaboration with customers

- Principle 2: Use an iterative design approach that results in minimum marketable products

- Principle 3: Prioritize schedule by off-ramping capabilities when necessary

- Principle 4: Collect customer feedback to inform improvements to the minimum marketable product

Source: GAO summary of corporate information. | GAO-22-104513

Leading Companies Follow a Common Set of Activities to Develop New Products

Figure 5: Leading Companies Share Common Product Development Activities

Leading Companies Follow a Common Set of Activities to Develop New Products

Interactive Graphic

Rollover the icon to see description. See appendix II for the non-interactive, printer-friendly version.

Figure 5: Leading Companies Share Common Product Development Activities

We found that while the individual details varied, leading company representatives we interviewed described a common set of activities, through which their companies conceptualize and realize a new product. These activities are shown in figure 5 and described in additional detail below.

A — CONCEPT

B — SCOPING

C — REQUIREMENTS

D — DESIGN

E — BUILD PROTOTYPE

F — TEST PROTOTYPE

G — MANUFACTURING AND SHIPPING

H — PRODUCT SUPPORT

Source: GAO. | GAO-22-104513

Text of Figure 5: Leading Companies Share Common Product Development Activities

We found that while the individual details varied, leading company representatives we interviewed described a common set of activities, through which their companies conceptualize and realize a new product. These activities are shown in figure 5 and described in additional detail below.

A. Concept: Product development begins with companies exploring product concepts and selecting a product to invest in and pursue. Leading companies undertake this exploration as part of an annual planning process with senior leadership. The process concludes with formation of a project team assigned to develop the selected concept.

B. Scope: After completing concept development and assembling the project team, senior leadership provides limited initial funding to the project team to begin their work. Senior leadership also sets guidelines for obtaining future funding based on product development progress. The project team then begins planning and scoping desired capabilities for the product and completes initial cost and schedule estimates for attaining those capabilities.

C. Requirements: Following the scoping phase, the project team and senior leadership develop and finalize requirements for the product. These requirements are comprised of the desired capabilities that can be developed within identified cost and schedule constraints. In essence, the company articulates the functions and features it wants the product to have, and how long it will take and how much it will cost to develop them.

D. Design: The project team begins developing the product design once senior leadership approves product requirements. At this point, senior leadership provides additional funding to build and test prototypes to integrate technologies, identify any design deficiencies based on tests and user feedback, and validate manufacturing processes. This design-build-test cycle repeats until the project team is satisfied the product design reflects a marketable product and is ready for manufacturing.

E. Build Prototype (see above)

F. Test Prototype (see above)

G. Manufacture and Shipping: After finalizing product design, leading companies survey the market to ensure that customers still want the planned product. Provided that customer demand persists, senior leadership provides additional funding to begin manufacturing and shipping. If demand has diminished, the company moves on to another effort.

H. Product Support: After the product has been released to end users—either in the marketplace or shipped directly to customers—leading companies transition to providing product support to their customers. As part of this phase of development, the company solicits user feedback on the product's design and performance.

Source: GAO. | GAO-22-104513

Leading Companies Employ Four Key Principles throughout Product Development

Four key principles underpin leading companies' product development activities. These principles, taken together, enable companies to deliver new products with speed to market. This speed to market calculation is relative to different product types and industries. For example, IBM development time frames for cloud computing software are typically 5 months, while Merck's timeline for developing a new pharmaceutical can span more than 7 years. Companies have their own unique considerations that drive time frames for product development. Merck, for example, indicated that its product development timelines are dependent on factors including the disease state and opportunities relative to standard of care, among others. Nonetheless, both companies are delivering new products on a schedule needed to meet customer needs and satisfy market demand. The four key principles, detailed below, enable leading companies to deliver products customers need with speed and efficiency.

Principle 1: Attain a Sound Business Case that Is Informed by Research along with Collaboration with Customers

For the first leading practices principle, we identified seven sub-principles, shown in Figure 6, that address how leading companies conduct market research and obtain and use customer feedback to establish a business case prior to product development and maintain it continually throughout product development.

Figure 6: Leading Companies Apply Seven Sub-Principles in Attaining Sound Business Case

PRINCIPLE
Attain a sound business case that is informed by research along with collaboration with customers

Sub-principles

1) Invest time to research a marketable product.

2) Solicit early feedback from customers for both hardware and software development.

3) Develop cost/schedule/performance tenets, or parameters, to define project goals before allocating initial funding.

4) Preserve institutional memory and share corporate knowledge in order to develop initial estimates, avoid earlier mistakes, and build on previous success.

5) Continuously evaluate cost, schedule, and performance parameters to ensure a high level of confidence in the project team's ability to deliver the product within cost and schedule targets prior to committing to a public release date.

6) Employ right-sized teams that have sufficient experience and autonomy to develop the product.

7) Willing to end product development if the product no longer has a sound business case.

Source: GAO summary of company information. | GAO-22-104513

Text of Figure 6: Leading Companies Apply Seven Sub-Principles in Attaining Sound Business Case

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6. Employ right-sized teams that have sufficient experience and autonomy to develop the product.

7. Willing to end product development if the product no longer has a sound business case.

Source: GAO summary of company information. | GAO-22-104513

Invest Time to Research a Marketable Product

We found that leading companies take time to determine whether there is a market for a proposed product. These leading companies seek to maximize their return on investment by ensuring there is customer demand. For example:

- **GE Renewable Energy** makes assumptions about the market demand for renewable energy products, such as alternative products to wind turbines, in order to make profitable products.

- **Qualcomm** talks to customers and completes engineering studies to conduct market research.

- As a construction company, **Kiewit Corporation** implements a variety of alternative delivery methods that incorporate the benefits of an integrated approach such as design-build construction model—under which the company is responsible for both designing and constructing the project. Kiewit's model of controlling risk by managing both the engineering and construction of complex projects is based on qualitative data and market research. Similar to the ways other companies research product development, Kiewit researches attributes of the project delivery process that influence market competitiveness.

Solicit Early Feedback from Customers for Both Hardware and Software Development

We found that obtaining feedback from new and existing customers for a potential product is an important aspect to attaining a sound business case for leading companies. For example:

- **Gulfstream Aerospace Corporation** asks customers questions about preferences on a range of topics, such as desired noise level or the use of renewable fuels, prior to initiating a project.

- **SpaceX** focuses heavily on internally-driven technologies, but generally does not pursue development for which there is no existing or expected customer business case. Customer-based product development, then, provides a source of funds for

space exploration that allows SpaceX to pursue its overall mission of establishing a human presence on the Moon and Mars.

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Amazon's Use of the Press Release/Frequently Asked Questions Document

When starting development of a new product, Amazon teams think first about the customer experience and then work backwards from that point. Central to this idea is that a product development effort begins with a press release and a frequently asked questions (FAQ) document. This internal document includes a potential press release and potential FAQs for the product. The press release should outline the intended customer and the key proposition for the customer—why they should care and why this product would be the customer's best option—in easy-to-understand language. It should establish what makes this product unique in order to gain approval by senior leadership.

Source: GAO summary of Amazon information. | GAO-22-104513

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Develop Cost, Schedule, and Performance Parameters

We found that leading companies define the goals of the product under development using cost, schedule, and performance tenets, or parameters, before allocating initial funding to the product development project. These tenets act as guideposts for project teams for how much a product development effort should cost, how long it should take, and what capabilities the product should provide. For example:

- Prior to receiving a commitment to a product development project, product development teams at **Qualcomm** present the business case to senior leadership, which demonstrates what is possible given a set of cost, schedule, and performance parameters.

- In addition to cost, schedule, and performance tenets, **Amazon** includes other criteria in its PR/FAQ to guide product development, such as specific compliance or privacy requirements.

- **SpaceX** incorporates customer requirements and objectives into its development efforts in addition to its own internal cost, schedule, and performance parameters.

Preserve Institutional Memory and Share Corporate Knowledge

We found that the leading companies in our review established processes—formal and informal—for preserving institutional memory and sharing corporate knowledge. Leading companies use these processes to develop initial cost and schedule estimates, avoid mistakes that previous product development project teams encountered, and build on prior successes. For example:

- **Derecktor** uses a computer-based historical record of past work to come up with an estimate of labor hours it will take for new ship construction. The company also relies on the experience and knowledge of the supervisors reviewing those estimates to determine if the estimates are reasonable.

- **Amazon** developed a formal process, a platform known as the Archive—a repository that captures what did or did not work on a previous development project. If an employee proposes a new effort of a previous project that failed, Amazon leadership has the ability to go back to the Archive to understand if the reasons for the failed project have fundamentally changed. If those reasons have changed, Amazon can go forward with the product idea. If the reasons have not changed, the decision is most likely to be no.

Kiewit's InEight Software Provides Institutional Memory with Insight into Past Performance

Kiewit developed the InEight software to provide project management, document management, and virtual design and construction tools, among others, to its workforce. The software also utilizes artificial intelligence (AI) to help inform schedule. As a result, management can look at projects the company built over time and project what a current project will cost and how long it will take. The company can aggregate historical data from previous clients and what Kiewit provided them. If a current client wants a project to go faster, Kiewit can piece together parts from prior schedules using the AI technology to obtain those schedule goals. For example, Kiewit might use different shift arrangements based on the productivity it achieved in similar work on a prior project. The cloud-based software also allows contract data to be shared with project teams in the field, allowing management to collect data on what is being accomplished on a daily basis and compare this with the contract module. These data can then be integrated with the forecast module and updated in real time. The more real-time data Kiewit can manage, the quicker practitioners can make adjustments in the field, saving overall costs.

Source: GAO summary of Kiewit information. | GAO-22-104513

Evaluate Cost, Schedule, and Performance Parameters Continuously

In addition to initially ensuring project teams can deliver products within cost and schedule targets, leading companies in our review continuously—meaning at recurrent intervals—evaluate cost, schedule, and performance parameters before committing to a public release date. By doing so, leading companies increase their confidence that the product will meet those cost, schedule, and performance targets and can take corrective actions, if necessary, to avoid cost or schedule overruns. For example:

- Only after **Qualcomm** has conducted initial engineering efforts and refined its cost estimates does the company commit to actually building the project. At that point, the

company establishes a budget and sets a committed date for the first customer shipment.

- **GE Renewable Energy** continuously evaluates cost and schedule estimates and reaches a high confidence level that they can execute its program cost and schedule goals within 10 percent of target before publicly announcing the product in development.

Employ Right-Sized Teams

We found that leading companies in our review took steps to equip and empower project teams with people who together have sufficient experience and skill sets needed to make the product development succeed. Further, they afford high degrees of independence and autonomy to those teams to develop their respective products. For example:

- **SpaceX** engineers are given large amounts of work and ownership. This approach creates a culture where an individual engineer is challenged and pushed to innovate. SpaceX's focus on right-sizing teams, rather than having large, overfull teams, means individual subsystem engineers are expected to regularly coordinate with engineers of other subsystems with which their subsystems interact.

- **Amazon** credits its successful product development efforts to its decentralized team structure, smaller team sizes, and the ability of those teams to operate independently.

Qualcomm Provides Its Engineers and Project Teams with Project Autonomy

At **Qualcomm**, each component of a product has a project engineer who is responsible for delivering the component. These project engineers have the authority and responsibility to have processes and practices in place for product development. The engineers have a sense of ownership of products, and they want to push products to be the best because they know they are responsible for that product's success. This sense of empowerment and autonomy is one thing the company credits its success to—if an engineer's design is approved, that engineer is empowered and motivated, and will put forth the extra effort to make sure the design works.

Source: GAO summary of Qualcomm information. | GAO-22-104513

End Product Development If Needed

Rather than continue to invest time and resources, we found that the leading companies in our review will act decisively to terminate a product development if they judge that the underlying business case for the product has deteriorated and is no longer sound, enabled by continued evaluation of that business case. For example:

- When **Merck** discontinues projects that are not meeting required efficacy and safety levels, it does so quickly. If a project fails, Merck decides whether or not to return to the idea based on what it anticipates the patient needs will be in the future.

- **Siemens** considers multiple factors, including availability of materials and the company's ability to produce according to plan. The company has a suite of tools to track performance and is able to see every component of development to track possible problems and warning signs. If a product becomes nonviable, often due to rising internal engineering costs, the company may decide to terminate the product.

Principle 2: Use an Iterative Design Approach That Results in Minimum Marketable Products

With regard to the second principle, we identified three sub-principles, shown in figure 7, that leading companies follow when using an iterative design approach that results in a minimum marketable product—one with the minimum capabilities needed for customers to recognize value.

Figure 7: Leading Companies Apply Three Sub-Principles in an Iterative Design Approach

PRINCIPLE
Use an iterative design approach that results in minimum marketable products

Sub-principles

1) Use modern design tools during both hardware and software development that enable multiple design iterations.

2) Use elements of Agile development methodologies that promote iteration in both hardware and software product development.

3) Use iterative design and testing to identify a minimum marketable product that can be followed by successive updates for both hardware and software development.

Source: GAO summary of company information. | GAO-22-104513

Text of Figure 7: Leading Companies Apply Three Sub-Principles in an Iterative Design Approach

1. Use modern design tools during both hardware and software development that enable multiple design iterations.

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3. Use iterative design and testing to identify a minimum marketable product that can be followed by successive updates for both hardware and software development.

Source: GAO summary of company information. | GAO-22-104513

Use Modern Design Tools

We found that leading companies in our review use modern design tools, such as digital engineering and additive manufacturing, throughout development for both hardware and software. Digital engineering—specifically, digital twins—allows companies to create virtual representations of their physical products to enable efficiencies during the design-build-test phase of development.

Leading company representatives provided us examples of how they used digital engineering to iterate on design, including the following:

- **GE Renewable Energy** digitally builds a wind turbine before putting it into production. The machine head on a wind turbine consists of approximately 1,300 parts. Building the machine head digitally enables GE to identify potential problems and determine how to resolve them, prior to actual production.

- **Siemens** makes extensive use of digital engineering to iterate on product design. In addition to modeling final products, such as a ventilator, the company also models the facilities where it manufactures those products.

Additive manufacturing, often referred to as 3D printing, also enables companies to rapidly design-build-test early prototypes of products.[32] It can also provide efficiencies through the product development process. For example:

- **Gulfstream** uses 3D printing to support quick design iterations of aircraft components.

- **GE Renewable Energy** prints facsimiles of parts to help manufacturers understand how parts will operate together and to identify any potential problems before producing large quantities for its wind turbines.

- Prior to the advent of additive manufacturing, replacing broken parts on the gas turbines at a **Siemens** manufacturing plant used to take several months, requiring the plant to slow production for extended periods of time. Now, the company prints its own parts on-site in 3D, allowing it to make repairs within hours and days.

Use Elements of Agile Development Methodologies

We found that the leading companies in our review use Agile development methodologies to promote iteration in both hardware and software product development.

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[32]Additive manufacturing is the industrial production name for 3D printing, a computer controlled process that creates three-dimensional objects by depositing materials, usually in layers.

We previously reported that the most well-known feature of Agile software development is its emphasis on iterative product development and delivery—that is, development of software in iterations that are being continuously evaluated on their functionality quality and customer satisfaction.[33] For example:

- **IBM** incorporates Agile concepts into its development teams by using iteration to speed development of its software.

SpaceX Follows an Agile Development Process to Develop Its Launch Vehicles

SpaceX incorporates the concept of a minimum viable product from the Agile software development approach to maximize speed and iteration in developing its launch vehicles. For example, launch vehicle designs are continuously evolving under its Agile processes. Instead of wasting resources to figure out each requirement up front, SpaceX learns more by building an approximation than by thinking about the final product. The use of Agile processes reduces the risk of continuing to fund a particular approach to development because funds have already been spent on that approach, even when the company realizes it is a less effective approach to development.

Source: GAO summary of SpaceX information. | GAO-22-104513

Use Iterative Design and Testing to Identify a Minimum Marketable Product

We found that leading companies in our review use iterative design and testing to identify a minimum marketable product that can be followed by successive updates to that product. Central to this concept is that leading companies recognize the minimum capabilities needed to deliver a product to the market that customers want. For example:

- **Amazon** uses the concept of a minimum loveable product—a product that will appeal to Amazon customers and will be something they will value.
- **SpaceX** focuses on rapidly iterating through a design-build-test approach, seeking to maximize both speed and iteration in product development and avoid spending excessive time over-specifying requirements. Rather than trying to determine every requirement, the company focuses on identifying a level of functionality to accomplish a reasonable approximation of the final product, with an expectation for continued innovation after a capability is debuted.
- **Derecktor** iterates on design so that its commercial ships can fulfill different roles. For example, for the first three ships using hybrid electric propulsion that Derecktor

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[33]GAO, *Agile Assessment Guide: Best Practices for Agile Adoption and Implementation*, GAO-20-590G (Washington, D.C.: September 2020).

constructed, the overall length and ship mechanics were the same. However, the interior layout of the ship changed based on customer preference or the intended end-use of the ship. In addition, Derecktor iterated on the design of one of the hybrid electric ships to transport groceries from Long Island, New York, to Connecticut to avoid vehicular traffic, as part of the Department of Transportation's Marine Transportation Highway Initiative.

Principle 3: Prioritize Schedule by Off-Ramping Capabilities When Necessary

With regard to the third principle, we found three sub-principles, shown in figure 8, support leading companies in focusing on schedule by intentionally deferring or canceling capabilities based on user feedback, when necessary.

Figure 8: Leading Companies Apply Three Sub-Principles in Off-Ramping Capabilities

PRINCIPLE
Prioritize schedule by off-ramping capabilities when necessary

Sub-principles

1) Use periodic reviews throughout the product development process to monitor project performance, and take steps to ensure development remains on course.

2) Maintain a realistic assessment of product development activities, with a willingness to make difficult decisions about capabilities.

3) Off-ramp capabilities that present a risk to delivering the product on schedule.

Source: GAO summary of company information. | GAO-22-104513

Text of Figure 8: Leading Companies Apply Three Sub-Principles in Off-Ramping Capabilities

1. Use periodic reviews throughout the product development process to monitor project performance, and take steps to ensure development remains on course.

2. Maintain a realistic assessment of product development activities, with a willingness to make difficult decisions about capabilities.

3. Off-ramp capabilities that present a risk to delivering the product on schedule.

Source: GAO summary of company information. | GAO-22-104513

Conduct Oversight through Periodic Reviews

We found that the leading companies in our review conduct periodic reviews throughout the product development process to monitor project performance and to take steps to ensure development remains on course. These reviews are intended to ensure that the product development process remains on schedule and within cost and can include multiple levels of management. Further, these reviews establish whether additional funding is warranted based on project progress. For example:

- **Merck** relies on oversight committees for all products as those products move through the development process. These oversight committees primarily monitor the efficacy and safety of pharmaceuticals in development, as well as cost and schedule.

- **Qualcomm** conducts major milestone reviews—during which senior leadership commits to a product development project—as well as operational reviews, annual reviews, and quarterly business reviews, which involve lower-level management. The company allows lower-level management to make decisions because those individuals have the requisite knowledge.

- The product development process at **Amazon** includes established milestone reviews that involve senior leadership along with stakeholders from across the company. The company tries to find the appropriate level of oversight to ensure project success.

Maintain a Realistic Assessment of Product Development Activities

We found that throughout development, the leading companies in our review focus on realism—what can be achieved—rather than optimism—what is hoped to be achieved. As a result, these leading companies are willing to make difficult decisions about capabilities. For example:

- As **Merck** develops formulas for pharmaceuticals, it may add back up compounds to the development program to provide options for continued investigation in the event that the lead candidate does not perform as expected.

- **Gulfstream** manages aircraft feature content as a means for maintaining aircraft production schedule. Project teams are willing to forgo some technological innovation as needed for the sake of meeting product release deadlines. However, safety always has a top priority over schedule.

- When **Kiewit** presents an engineering and construction schedule to a client early, there are opportunities to minimize construction and design challenges. For example, early contractor engagement allows Kiewit to discuss the scope of what can be built, within the schedule, for the target price. The engagement allows the client and Kiewit to work off the same priorities and allocation of risk.

<u>Off-ramp Capabilities as Needed</u>

Closely related to the concept of maintaining a realistic assessment of product development activities and a willingness to make difficult decisions about product capabilities, we found that the leading companies we reviewed will make an intentional decision to off-ramp capabilities that present a risk to delivering, on schedule, the capability prioritized by customers. For example:

- When **Gulfstream** encounters technical challenges that will negatively impact schedule, it will plan to off-ramp individual features that are not critical to the overall product.

- **Siemens'** production schedules are set to accommodate the features that are most critical to the customer. The company considers opportunities to off-ramp product features, as necessary, if they turn out not to be critical to the customer.

- Once **Qualcomm** commits to a schedule, it may identify some features that present a risk to delivering customer priorities on time and decide to address those features in the next delivery iteration instead. While this decision may be difficult, it helps ensure the ultimate superiority of the product—and representatives said that "good enough on time" is preferred to "perfect but late."

Principle 4: Collect Customer Feedback to Inform Improvements to the Minimum Marketable Product

Regarding the fourth principle, we identified two sub-principles, shown in figure 9, that support the principle that leading companies collect customer feedback as a way to inform improvements to the minimum marketable product.

Figure 9: Leading Companies Apply Two Sub-Principles in Collecting Customer Feedback to Inform Improvements

PRINCIPLE
Collect customer feedback to inform improvements to the minimum marketable product
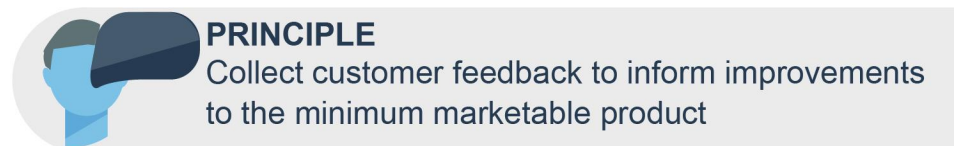
Sub-principles

1) Establish a process to facilitate ongoing engagement with customers after product release.

2) Use customer feedback to identify challenges to address and new features to include in subsequent releases.

Source: GAO summary of company information. | GAO-22-104513

Text of Figure 9: Leading Companies Apply Two Sub-Principles in Collecting Customer Feedback to Inform Improvements

1. Establish a process to facilitate ongoing engagement with customers after product release.

2. Use customer feedback to identify challenges to address and new features to include in subsequent releases.

Source: GAO summary of company information. | GAO-22-104513

Establish a Process for Ongoing Customer Engagement

We found that the leading companies we reviewed prioritize customer engagement and establish a process to facilitate customer feedback. For example:

- **Qualcomm** uses a time-box method of development, with a series of releases related to the engineering time and capabilities that it will have in each fixed period of development. Qualcomm will prioritize the features in each release based on user feedback, and in some cases will move features from a later release to the current release in order to satisfy user needs.

- **Amazon** builds customer support into its product plan and considers product support and product maintenance from the beginning of development. The company also has a product management team that meets with customers frequently to get their feedback on what features they want included during product development. A product launch at Amazon is not a finish line, but represents reaching the starting line.

- **Gulfstream** provides multiple forms of customer support. When new products enter into service, the company sends an accompanying aircrew to provide support for up to 30 days, depending on the customer. It also retains multiple customer engagement teams that focus on issues customers experience post-aircraft delivery.

Use Customer Feedback in Subsequent Releases

In addition to establishing a process to collect customer feedback, we found that the leading companies in our review use that feedback to identify problems with the product and new features customers want in future releases. For example:

- The sales and marketing teams for **Carnival Corporation** use end-of-cruise scorecards and focus groups to determine features guests want on future cruise ships.

- **Derecktor** tracks client feedback after each ship is launched. Depending on the nature of the feedback after delivery, the company will incorporate solutions to problems on new projects in development.

- **Gulfstream** hosts customer review boards twice a year to ask clients what problems they encountered and where the company could improve.

- **Amazon** continuously monitors failure modes on its products and services to understand what was missed in development. Amazon can then use that information to fix the problem, if it can be done with software, and inform testing in future product development projects.

Agency Acquisition Policies Implement Some, but not All, Key Product Development Principles, Missing Opportunities to Improve Outcomes

We found that DOD, DHS, and NASA each partially implement, in policy, many of the key product development principles we identified from selected leading companies. Figure 10 depicts the extent to which the agencies' acquisition policies reflect concepts related to the four principles outlined above. For example, just as leading companies emphasize a minimum marketable product, a government acquisition can benefit from accepting a product design that meets initial capabilities followed by subsequent iterations or releases, which we found reflected in some agency policies. Further, senior officials at these three agencies generally endorsed the applicability of these principles to their acquisition programs, but often the principles are employed in practice rather than enshrined in policy. The following sections detail the extent to which our analysis found agency policies aligned with key product development principles.

Figure 10: Extent to Which Agency Acquisition Policies Implement Key Product Development Principles

Key principle	Department of Defense (DOD)	Department of Homeland Security (DHS)	National Aeronautics and Space Administration (NASA)
Attain a sound business case	partially	partially	fully
Use an iterative design	partially	partially	partially
Prioritize schedule	partially	partially	fully
Collect customer feedback	partially	fully	partially

Agency policies **do not** implement the majority of the sub-principles in the key principle

Agency policies **partially** implement the majority of the sub-principles in the key principle

Agency policies **fully** implement all of the sub-principles in the key principle

Source: GAO analysis of DOD, DHS, and NASA primary acquisition policies and interviews with agency officials. | GAO-22-104513

Data table for Figure 10: Extent to Which Agency Acquisition Policies Implement Key Product Development Principles

Key Principle	Dept of Defense (DOD	Dept of Homeland Security (DHS)	National Aeronautics and Space Administration (NASA)
Attain a sound business case	Partially implemented	Partially implemented	Fully implemented
Use an interactive design	Partially implemented	Partially implemented	Partially implemented
Prioritize schedule	Partially implemented	Partially implemented	Fully implemented
Collect customer feedback	Partially implemented	Fully implemented	Partially implemented

Source: GAO analysis of DOD, DHS, and NASA primary acquisition policies and interviews with agency officials. | GAO-22-104513

Note: For each agency, we determined the extent to which primary acquisition policies include language reflecting the key principles and sub-principles of product development that our work identified.

DOD Policies Partially Implement Key Product Development Principles

DOD primary, department-wide acquisition policies partially implement all four key product development principles. These policies include multiple examples of guidance for attaining a sound business case, iterating on design, prioritizing schedule through a realistic assessment of product development activities, and collecting end-user feedback. However, we found that in many cases this guidance was limited to certain product types—such as software applications—and does not generally apply across all acquisition programs. Appendix III provides our detailed analysis of DOD policy alignment with the sub-principles for each key principle.

DOD officials told us that in some cases these principles are already employed through informal practices, such as working groups, forums, or in lower-level guidance. However, incorporating the principles into policies would facilitate more consistent implementation across DOD programs, particularly in an era of decentralized oversight of acquisition programs.

Principle 1: Attain a Sound Business Case that Is Informed by Research along with Collaboration with Customers

DOD policies partially implement most of the seven sub-principles that comprise this key principle. Specifically, we determined that DOD policies fully implement two sub-principles: (1) invest time to research a marketable product; and (2) develop cost, schedule, and performance tenets, or parameters, to define project goals before allocating initial funding. We also determined that DOD policies partially implement the following five sub-principles:

- Solicit early feedback from customers for both hardware and software development;
- Preserve institutional memory and share corporate knowledge;
- Evaluate cost, schedule, and performance parameters continuously;
- Employ right-sized teams; and
- End product development if needed.

Our analysis found that these five sub-principles are only partially implemented because of the limited instances in which they are reflected in DOD's policies. For example, DOD's software pathway policy is currently the only policy that requires incorporating early user feedback. In contrast, we found that leading companies solicit early user feedback for both hardware and software development.

DOD officials acknowledged opportunities to include language similar to that found within the software policy in other policies. DOD officials also told us that they implement some of these sub-principles in practice, such as preserving institutional knowledge through communities of practice, and sharing videos and vignettes on lessons learned across programs. Additionally, we identified Defense Acquisition University courses that teach elements of these sub-principles. However, if fully implemented in policy, this principle could help DOD programs avoid common mistakes from similar efforts and prevent the agency from investing resources into programs that lack a sound business case.

DOD Software Policy Includes the Sub-Principle of Employing Right-Sized Teams to Attain a Sound Business Case

Leading companies in our review equip and empower project teams with people who together have sufficient experience and skill sets needed for success. The DOD software policy requires that programs use small, empowered teams and scale larger efforts across multiple teams. The policy notes that this allows programs to continuously refine software development processes, practices, tools, and program strategies. While these provisions reflect leading company key principles, they only apply to acquisitions using the software pathway.

Source: GAO analysis of Department of Defense (DOD) Instruction 5000.87, *Operation of the Software Acquisition Pathway*, (Oct. 2, 2020). | GAO-22-104513

Principle 2: Use an Iterative Design Approach that Results in Minimum Marketable Products

We found that DOD policies partially implement the three sub-principles for this principle:

- Use modern design tools during both hardware and software development that enable multiple design iterations;

- Use elements of Agile development methodologies that promote iteration in both hardware and software product development; and

- Use iterative design and testing to identify a minimum marketable product that can be followed by successive updates for both hardware and software development.

However, DOD policies limit these sub-principles to singular policies and do not include those sub-principles in the department-wide policies for the AAF. For example, DOD's Testing and Evaluation policy requires programs to use models to digitally represent acquisitions systems in a mission context in order to conduct integrated tests. This application of design tools applies within the context of test and evaluation, which means programs can miss opportunities to learn from digital tools early in a program's development.

DOD Software Policy Reflects Key Sub-Principle of Using Agile Development to Promote Iteration

Leading companies use Agile development methodologies to promote iteration across both hardware and software product development efforts. DOD's software policy—DOD Instruction 5000.87—states that programs "will require government and contractor software teams to use modern iterative software development methodologies (e.g., Agile or lean), modern tools and techniques (e.g., development, security, and operations [DevSecOps]), and human-centered design processes to iteratively deliver software to meet the users' priority needs." However, this policy applies only to efforts using the software pathway, limiting its applicability.

Source: GAO analysis of the Department of Defense (DOD) Instruction 5000.87, *Operation of the Software Acquisition Pathway* (Oct. 2, 2020). | GAO-22-104513

The software policy also includes aspects of an iterative design approach, but this policy only applies to efforts using the software pathway. DOD officials stated that they structured the AAF such that program officials can use requirements in one pathway in conjunction with another pathway. While the software policy, for example, presents a positive opportunity for software efforts in other pathways, we found that leading companies consistently employ iterative design principles for both software and hardware product development. Instilling the use of those same principles in the department-wide AAF policy that applies to all programs, rather than only providing programs with that option for specific software efforts, ensures use of this key principle and an increased chance of success throughout the program's life cycle.

Principle 3: Prioritize Schedule by Off-ramping Capabilities When Necessary

We found that DOD's policies partially implement all three sub-principles for this principle. These sub-principles include:

- Conduct periodic reviews throughout the product development process to monitor project performance, and take steps to ensure development remains on course;

- Maintain a realistic assessment of product development activities, with a willingness to make difficult decisions about capabilities; and

- Off-ramp capabilities that present a risk to delivering the product on schedule.

DOD Software Policy Reflects Key Sub-Principle of Prioritizing Schedule throughout Development by Off-Ramping Capabilities When Necessary

Leading companies will intentionally off-ramp non-critical capabilities based on user input when their continued development risks compromising the overall product schedule. DOD's software policy is consistent with this key principle. The policy requires program offices to maintain detailed lists or backlogs that identify and prioritize user needs. According to DOD Instruction 5000.87, these backlogs allow for "dynamic reallocation of current and planned software releases." Issues identified during development and operations are to be addressed in future iterations and releases. The policy further requires that programs commit to and obtain early and ongoing involvement from users to help prioritize capabilities and make trades, including in pace of delivery.

Source: GAO analysis of Department of Defense (DOD) Instruction 5000.87, *Operation of the Software Acquisition Pathway* (Oct. 2, 2020). | GAO-22-104513

DOD policies address portions—but not all aspects—of these sub-principles. For example, DOD Directive 5000.01 requires programs to establish baseline parameters and report any deviations from them, a requirement consistent with how leading companies conduct periodic reviews. However, the policy does not require programs to consider cutting problematic capabilities to meet schedule. Further, while major defense acquisition programs are subject to statutory reporting requirements if they exceed certain cost and schedule thresholds—consistent with key principles—these

requirements do not apply to all DOD acquisition programs.[34] DOD officials acknowledged that DOD does not currently employ a consistent process to off-ramp capabilities from programs. Officials said the department is exploring opportunities to improve its portfolio management. If implemented, such efforts could position DOD to make informed decisions on a program's capabilities when another program is already seeking to provide similar capabilities. However, DOD has yet to implement recommendations we made in 2015 to clarify and strengthen roles and responsibilities at the enterprise level for making portfolio management decisions.[35] Fully implementing this principle could help DOD programs deliver needed capabilities to users within cost and schedule goals.

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[34]10 U.S.C. §§ 4372-4374 (2022).

[35]GAO-21-119SP.
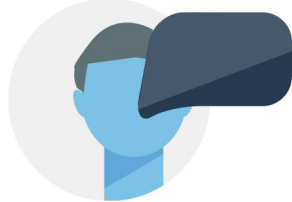
Principle 4: Collect Customer Feedback to Inform Improvements to the Minimum Marketable Product

DOD policies partially implement both of the sub-principles for this key principle:

- Establish a process to facilitate ongoing engagement with customers after product release; and

- Use customer feedback to identify challenges to address and new features to include in subsequent releases.

We found that DOD requires programs to establish a process to facilitate ongoing engagement with customers—the soldiers, sailors, or other end users of the weapon system—after product release within its software pathway. For example, DOD's software policy establishes value assessments, which programs are to perform at least annually after fielding software to determine if the mission improvements or efficiencies realized from the delivered software are timely and worth the current and future investments from the end-user perspective.[36]

Similarly, we found that DOD's software pathway requires programs to use customer feedback to identify challenges to address and what new features to include in subsequent releases. The purpose of the planning stage of the software pathway is to better understand the users' needs and plan the approach to deliver software capabilities to meet those needs.[37] Leading companies, by comparison, facilitate this customer feedback across all program types, not just software.

Additionally, the product support management policy addresses ways for programs to incorporate the user community during testing. Specifically, the policy requires the product support manager for programs to "work with systems engineers and the testing and user communities to incorporate the costs and manpower planning necessary to conduct user supportability related demonstration and evaluation events into the program test strategy."[38] DOD's Directive 5000.01 and Instruction 5000.02, which provide the department-wide management principles that govern the defense acquisition system, do not address the use of end-user feedback in any capacity. In our review of leading companies, all product types used customer feedback to establish the

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[36]DOD Instruction 5000.87.

[37]DOD Instruction 5000.87.

[38]DOD Instruction 5000.91.

requirements for the subsequent releases of a product, based on the customer concerns with the current product.

DOD acquisition policy officials stated that the Joint Staff fulfill this role when they talk to the Combatant Commands to determine capability needs. For example, the Joint Staff conducts an annual Capability Gap Assessment to determine how new acquisition programs can fill those gaps, such as with the Urgent Capability pathway. According to DOD officials, the Joint Staff also conducts annual visits to provide training on capabilities and requirements, which they said is one of the mechanisms they use to assess current capability and generate real-time user needs.[39] While some DOD practices do address user feedback, a required policy with mechanisms to solicit and incorporate user feedback that extends to all DOD acquisition programs would better position programs to understand user needs and develop capabilities to meet those needs.

> **DOD Product Support Management Policy Reflects Aspects of the Key Sub-Principle of Collecting Customer Feedback to Inform Improvements to the Minimum Viable Product**
>
> Leading companies establish a process to facilitate ongoing engagement with customers after product release in order to inform improvements to the minimum viable product. DOD's Product Management Support policy requires product support managers to work with systems engineers and the testing and user communities to ensure there is enough product support in the testing strategy to conduct user supportability related demonstrations across all pathways. This provision aligns with the principle of establishing a process of engaging with customers, but only requires that engagement during the testing phase, and not after product release.
>
> Source: GAO analysis of Department of Defense (DOD) Instruction 5000.91, *Product Support Management for the Adaptive Acquisition Framework* (Nov. 4, 2021). | GAO-22-104513

DHS Acquisition Policies Partially or Fully Implement Key Product Development Principles

DHS primary, department-wide policies fully implement one key product development principle and partially implement the remaining three principles. The policies fully implement sub-principles relating to collecting end-user feedback and include several elements that emphasize developing and sustaining a sound business case, iterating on design, and prioritizing schedule. However, we identified several sub-principles common

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[39]The Joint Staff has enterprise-level responsibilities related to the requirements process, including identifying, assessing, validating, and prioritizing capability needs.

to product development in leading companies that are not fully implemented by the agency's existing policies. DHS policies do not include provisions for:

- sharing lessons learned with future programs,

- terminating programs or off-ramping capabilities in the event of schedule challenges,

- encouraging contractors to use modern tools to facilitate iterative design, or

- requiring the development of minimum viable products for hardware systems.

Appendix IV presents our detailed analysis of DHS policy alignment with the sub-principles for each key principle. Without full implementation of the key principles in acquisition policy, DHS misses opportunities to improve the speed and efficiency of its acquisition life cycle. DHS officials told us that some of the sub-principles that are not implemented in policy are, nevertheless, activities that agency programs generally conduct in practice. For example, they reported that acquisition officials from across the agency regularly participate in forums to share lessons learned. However, by fully incorporating these key principles in agency policy, DHS would be better positioned to promote their consistent application across programs.

Principle 1: Attain a Sound Business Case that Is Informed by Research along with Collaboration with Customers

DHS policies at least partially implement the majority of the seven sub-principles within this key principle. Specifically, we determined that DHS policies fully implement five sub-principles:

- Invest time to research a marketable product;

- Solicit early feedback from customers for both hardware and software development;

- Develop cost, schedule, and performance parameters to define project goals;

- Continuously evaluate cost, schedule, and performance parameters to ensure a high level of confidence in the project team's ability to deliver the product within cost and schedule targets; and

- Employ right-sized teams that have sufficient experience and autonomy to develop the project.

However, we found that DHS policies only partially implement the sub-principle of preserving institutional memory and sharing knowledge in order to develop initial

estimates, avoid earlier mistakes, and build on previous successes. The Systems Engineering Life Cycle Instruction requires programs to capture lessons learned, but does not require them to share their lessons with other programs across the agency.

We also found that DHS acquisition policies did not implement the sub-principle of willingness to cease product development if the product no longer has a sound business case. DHS policies do not require program teams to consider a program for termination in case of a breach of cost or schedule parameters, if the reasons for the breach may warrant that consideration. DHS's Acquisition Management Instruction states that a program may be cancelled or terminated "for any number of reasons."[40] However, those reasons are not defined, and no guidance is given to consider a program for termination in case of a breach of cost or schedule parameters. DHS officials told us that program termination is a significant decision requiring approval from the Secretary of Homeland Security. Therefore, the agency prefers to pursue remediation options before considering a program for termination in the case of a breach. If fully implemented in policy, the sub-principles in this key principle could help DHS program teams avoid the planning mistakes of earlier programs and prevent the agency from investing resources into programs that lacked a sound business case.

DHS Policy Partially Implements Sub-Principle on Lessons Learned

The Systems Engineering Life Cycle Instruction requires programs to conduct post implementation reviews that determine whether the implemented solution meets mission outcomes and provides anticipated benefits; identify deficiencies; recommend how mission outcomes may be better achieved; and capture lessons learned. Moreover, in response to a prior GAO recommendation, DHS updated its Post Implementation Review Guidance for Acquisition Programs to standardize analysis elements of the post implementation reviews.

However, although policy requires that programs conduct post implementation reviews, it does not require program compliance with the new guidance about how to conduct post implementation reviews. Further, the agency's department-wide acquisition policies do not outline a consistent method to share lessons learned across the agency. Policies also do not require programs to incorporate the lessons learned by earlier program teams into their initial plans.

Source: GAO analysis of Department of Homeland Security (DHS) Instruction 102-01-103, *Systems Engineering Life Cycle* (Feb.4, 2021); DHS Post Implementation Review Guidance for Acquisition Programs (Feb.24, 2020). | GAO-22-104513

DHS officials told us that the agency has many opportunities in practice for lessons learned to be shared. For example, the officials reported regularly occurring forums with

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[40]DHS Acquisition Management Instruction 102-01-001.

acquisition officials from across the agency, and an annual symposium to share presentations on lessons learned. They also told us that the Coast Guard maintained a lessons learned database, though no such resource was available across all components. However, they acknowledged that DHS policy had no requirement for program managers to research prior programs' lessons learned before starting a program.
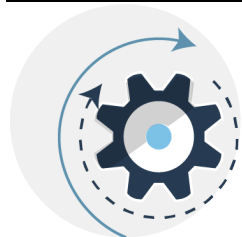
Principle 2: Use an Iterative Design Approach that Results in Minimum Marketable Products

DHS policies at least partially implement the majority of the three sub-principles within this key principle. Specifically, we determined that DHS policies fully implement one sub-principle—use elements of Agile development methodologies that promote iteration in both hardware and software product development. DHS policies also partially implement the sub-principle of using iterative design and testing to identify a minimum marketable product that can be followed by successive updates. Though DHS policy requires all programs to use an iterative design and testing approach, only incremental software development programs use this iterative process to identify a minimum viable product. Further, we found that DHS policies do not implement the sub-principle of using modern tools to facilitate iterative design.

We found that leading companies use iterative design to identify a minimum viable product for both software and hardware development. DHS officials acknowledged that the agency's acquisition policies did not require programs to identify a minimum viable product, but said that many programs did release new capabilities incrementally in practice. None of the policies we reviewed reference the use of modern design tools or practices. DHS officials told us that details such as the use of specific tools could be found in individual contracts, on a case-by-case basis, rather than consistently implemented through policy. We found that the consistent use of tools such as digital engineering and additive manufacturing help leading companies to move quickly and efficiently through the design process, and reduce the need for costly changes later in the product life cycle. If fully implemented, this principle could help DHS programs move quickly and efficiently through design, and reduce the need for costly changes late in the acquisition life cycle.

DHS Software Policy Requires Agile Development

Leading companies use elements of Agile development methodologies to promote iteration in product development. The DHS Agile Methodology for Software Development and Delivery for Information Technology policy states that DHS established Agile development as the required approach for software development and delivery for information technology programs and projects. It also notes the benefits of Agile development, specifically that it "promotes continuous adaptive planning, development, testing, delivery and integration, and encourages rapid and flexible response to change between self organizing and cross functional teams." These provisions reflect a sub-principle used by leading companies.

Source: GAO analysis of Department of Homeland Security (DHS) Instruction 102-01-004, *Agile Methodology for Software Development and Delivery for Information Technology* (Feb. 19, 2020). | GAO-22-104513

Principle 3: Prioritize Schedule by Off-Ramping Capabilities when Necessary

We found that DHS policies at least partially implement two of the three sub-principles within this key principle. We determined that DHS policies fully implement two sub-principles—DHS requires periodic reviews to monitor program performance and make difficult decisions about capabilities. But, we found that DHS policies do not implement one sub-principle—considering off-ramping capabilities that present a risk to delivering the product on schedule. The agency does not require programs to off-ramp or de-scope capabilities that pose a schedule threat.

We found that leading companies intentionally defer or cancel capabilities based on user feedback in order to prioritize schedule, when necessary. By off-ramping those features for future iterations of the product, leading companies are able to deliver other capabilities to the end user more quickly. DHS officials told us that, in practice, program managers are able to make trade-offs between capabilities that are not tied to key performance parameters. However, this authority is not outlined in policy. This principle could, if fully implemented in policy, help DHS programs to maintain cost and schedule goals and meet user needs in the face of challenges in executing plans.

DHS Policy Authorizes Program Managers to Make Difficult Decisions, but Not in Order to Preserve Schedule

DHS's Acquisition Management Instruction states that, if a program is not fully funded, the component must "identify the trade-offs necessary to fund the program within existing resources, or the Component must adjust scope and/or schedule to make the acquisition affordable." Although this policy provides programs the option to off-ramp capabilities in order to stay within budget, it does not require that they do so in order to preserve schedule. We found that leading companies prioritize schedule in cases where individual product features prove to be more difficult or resource-intensive than initially estimated. By off-ramping those features for future iterations of the product, leading companies are able to deliver other capabilities to the end user more quickly.

Source: GAO analysis of Department of Homeland Security (DHS) Instruction 102-01-001, *Acquisition Management Instruction* (Jan. 21, 2021). | GAO-22-104513
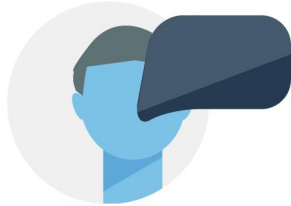
Principle 4: Collect Customer Feedback to Inform Improvements to the Minimum Marketable Product

DHS policies fully implement both of the sub-principles within this key principle. The policies establish a process to facilitate ongoing engagement with customers—component officials who are the end users of the systems—after product release, and use customer feedback to identify challenges to address and new features to include in subsequent releases. We found that DHS requires programs to collect user feedback at the end of product development and incorporate feedback from prior programs into initial considerations for new programs.

HS Policy Fully Implements the Sub-Principle of Collecting Customer Feedback

Leading companies establish a process to facilitate ongoing engagement with customers after product release. The DHS Systems Engineering Life Cycle Instruction requires that post implementation reviews be conducted to determine whether the implemented solution meets mission outcomes and provides anticipated benefits, and evaluate stakeholder and customer or user satisfaction with the end product. It also requires components to establish a Lead Business Authority for each program, who is responsible for "providing continuous feedback to the program on behalf of the user community."

Source: GAO analysis of Department of Homeland Security (DHS) Instruction 102-01-103, *Systems Engineering Life Cycle* (Feb. 4, 2021). | GAO-22-104513

NASA Policies Fully Implement Two of Four Key Product Development Principles

NASA primary, department-wide policies fully implement two key principles—attaining a sound business case and off-ramping capabilities when necessary. However, the policies do not fully implement two other key principles used by leading companies. NASA policies do not encourage an iterative design approach that results in minimum viable products, or collection of stakeholder feedback to improve project designs after product launch. Appendix V presents our detailed analysis of NASA policy implementation of the sub-principles that comprise each key principle.

Without full implementation of the key principles in its acquisition policy, NASA misses opportunities to increase the speed of its acquisition life cycle. NASA officials told us that some of the sub-principles that are not implemented in department-wide policy are, nevertheless, conducted by programs in practice or included in program-level documents. However, by fully incorporating these key principles in agency policy, NASA would be better positioned to promote their consistent application across all programs.

Principle 1: Attain a Sound Business Case that Is Informed by Research along with Collaboration with Customers

NASA policies fully implement all seven sub-principles within this key principle. We found that policies include:

- developing viable projects that meet identified needs;

- engaging end users in the program planning process;

- developing cost, schedule, and performance parameters;

- preserving institutional memory;

- ensuring a high level of confidence in the project team's ability to deliver products within cost and schedule targets;

- employing right-sized teams with sufficient experience and autonomy; and

- considering projects for termination if they failed to maintain a sound business case during development.

NASA Policy Fully Implements the Sub-Principle of Sharing Lessons Learned

Leading companies have established processes—formal and informal—for preserving institutional memory and sharing corporate knowledge in order to develop initial estimates, avoid earlier mistakes, and build on previous success. The NASA Space Flight Program and Project Management Requirements policy provides guidance for programs to capture lessons learned in a knowledge management plan and to consult prior programs' lessons learned while developing initial plans. Moreover, the Knowledge Policy for Programs and Projects describes multiple sources maintained by the agency for recording and sharing knowledge between programs. Sources include a Lessons Learned Information System, and the Academy of Program/Project and Engineering Leadership Knowledge Services website, where NASA's technical workforce can find knowledge needed to support project learning and mission success.

Source: GAO analysis of NASA Procedural Requirements 7120.5F, *NASA Space Flight Program and Project Management Requirements*; and NASA Policy Directive 7120.6A, *Knowledge Policy for Programs and Projects.* | GAO-22-104513
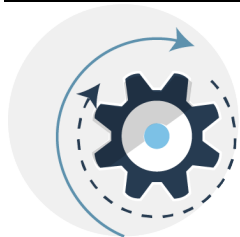
Principle 2: Use an Iterative Design Approach that Results in Minimum Marketable Products

NASA policies at least partially implement the majority of the sub-principles within this key principle. We found that NASA policies fully implement one sub-principle—use elements of Agile development methodologies that promote iteration in both hardware and software product development. NASA policies also partially implement another sub-principle—use modern design tools to enable multiple design iterations. NASA policies encourage the use of modern design techniques for software development but not for hardware. We found that leading companies utilize modern design tools such as digital twins and additive manufacturing for hardware as well as software design. NASA officials told us that requirements for contractors to use specific tools or techniques are made on a case-by-case basis but were not included in department-wide acquisition policy because they expect contractors to use cutting edge tools, which evolve over time.

Further, we found that NASA policies do not reflect the sub-principle of using iterative design and testing to identify a minimum marketable product that can be followed by

successive updates. NASA policies do not require programs to identify minimum viable products for either hardware or software development. Information technology programs may provide a proof of concept or prototype to be incorporated into later developments.[41] However, such technology demonstrations are not equivalent to minimum viable products used by leading companies, which are completed and deployed products that can be updated in subsequent releases. By focusing on the features that are most critical to customer needs, leading companies produce new capabilities more quickly than they would be able to do if programs were bogged down with less critical requirements.

NASA's major projects aim to explore Earth and the solar system, extend human presence beyond low Earth orbit to the lunar surface, and understand climate change, among other things. NASA officials told us that an important difference between leading companies' product development and NASA's project life cycle is that NASA cannot prototype in an operational environment. Due to the unique nature of NASA's mission, officials told us that programs cannot retrieve most products after launch for adjustments and upgrades, which limits their ability to plan for minimum viability. Officials also told us that they considered a minimum viable product to be one that met only the highest priority requirements necessary for mission viability. However, delivering a project that meets minimum requirements but does not leave open the possibility of successive updates does not align with the principle used by leading companies. By including opportunities for subsequent iterations on existing technology where appropriate in policy, NASA could help projects move more quickly and efficiently through design, and result in final products that meet the most essential mission requirements with greater speed.

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[41]NASA Procedural Requirements 7120.7A.

Principle 3: Prioritize Schedule by Off-Ramping Capabilities when Necessary

NASA Policy Fully Implements the Sub-Principle of Off-Ramping Capabilities as Needed

Leading companies will off-ramp non-critical capabilities that present a risk to delivering the product on schedule. The NASA Space Flight Program and Project Management Requirements policy provides guidance for projects to develop plans to off-ramp or de-scope capabilities to maintain cost and schedule goals. It states that a project's Technical, Schedule, and Cost Control Plan must "describe the project's de-scope plans, including key decision dates and savings in cost and schedule, and show how the de-scopes are related to the project's threshold performance requirements."

Source: GAO analysis of NASA Procedural Requirements 7120.5F, *NASA Space Flight Program and Project Management Requirements*. | GAO-22-104513

NASA policies fully implement all three sub-principles within this key principle. We found that NASA policies require programs and projects to conduct oversight through periodic reviews, to make difficult decisions about capabilities as necessary, and to consider options to de-scope projects that are not meeting cost and schedule targets.

Principle 4: Collect Customer Feedback to Inform Improvements to the Minimum Marketable Product

NASA policies fully implement one of the sub-principles within this key principle. We found that NASA programs and projects are generally required to comply with an international aerospace standard that requires organizations to obtain customer feedback related to products and services and monitor customer satisfaction. However, NASA policies do not require programs to use such feedback to identify challenges to

address or new features to include in subsequent releases. If fully implemented, this principle could help NASA projects meet stakeholder needs and allow stakeholder and end-user feedback to drive improvements in cases where projects have opportunities for upgrades or iterative releases.

NASA officials told us that stakeholder engagement is embedded in the project management process and that agency boards and councils ensure that stakeholder perspectives are considered throughout project development. For example, officials noted that Life Cycle Reviews and Key Decision Points provide opportunity to make sure NASA is building the right system. They also said that, for crewed space missions, they receive continuous feedback from the astronauts using the spacecraft, which informs design. However, mechanisms for capturing user feedback after product launch are not reflected in policy.

Additionally, officials noted that the users for most NASA projects are different from leading companies; they consider the agency's final product to be the science produced and their end users to be the science community that benefits from that science. Officials from various mission directorates told us that they collect customer feedback through various venues in practice. For example, the National Academy of Science's Decadal Studies and Decadal midterm reports provide the Science Mission Directorate with feedback regarding the direction and relevance of NASA science missions. However, these practices are not reflected in the agency's department-wide acquisition policies. Regardless of how the agency defines its end users, implementing consistent methods of obtaining feedback and incorporating that feedback into future product designs could help NASA to identify problems and improve product designs.

NASA Collects Some Customer Feedback in Practice

Leading companies establish processes to facilitate ongoing engagement with customers after product release. Though NASA policies do not include requirements to engage with customers after product launch, agency officials provided examples of how mission directorates collect such feedback informally in practice. For example, officials said that the Science Mission Directorate seeks and collects customer feedback through various venues, such as community town halls. Officials also told us that the Exploration Systems Development Mission Directorate conducts post flight reviews with astronauts, and that feedback is captured in lessons learned reports.

Source: GAO interviews with NASA officials. | GAO-22-104513

Conclusions

Leading companies consistently deliver new products to market that are on time, within planned costs, and provide capabilities that serve customers. In these companies, strong incentives—underpinned by four key principles—compel product development activities that prioritize speed to market. Delays pose real consequences, including diminished market share and erosion of a customer base, which leading companies refuse to accept.

Acquisition programs within DOD, DHS, and NASA do not face this same imperative. Suboptimal outcomes—in the form of cost growth, schedule delays, and performance shortfalls—occur regularly in these programs. Consequently, in this environment, end users of a new capability are left without recourse when promised capabilities are delivered late.

The dynamics that foster these divergent outcomes are complex and multifaceted. Acquisition policies are one factor in the success or shortfalls that occur in agency programs. Other factors, such as unique government acquisition structures and culture, also contribute and warrant ongoing attention. Agencies also report that they do address many of these principles and sub-principles in practices or through informal guidance. Nonetheless, the importance of having foundational acquisition policies rooted in the principles that drive successful product development within leading companies cannot be overstated. Thoughtful acquisition policies—ones that prioritize sound business cases and provide mechanisms for applying iterative design approaches, off-ramping capabilities, and incorporating feedback from users of initial capabilities—are vital to and provide a logical starting point for achieving better, more consistent outcomes across DOD, DHS, and NASA acquisition programs.

Recommendations for Executive Action

We are making a total of nine recommendations, including four to DOD, three to DHS, and two to NASA.

The Secretary of Defense should ensure that the Under Secretary of Defense for Acquisition and Sustainment update DOD acquisition policies to fully implement the following principles throughout development:

- attaining a sound business case (Recommendation 1);
- applying iterative design approaches (Recommendation 2);
- off-ramping capabilities when needed to maintain schedule (Recommendation 3); and
- incorporating feedback from users of initial capabilities (Recommendation 4).

The Secretary of Homeland Security should ensure that the DHS Undersecretary for Management update DHS acquisition policies to fully implement the following principles throughout development:

- attaining a sound business case (Recommendation 5);
- applying iterative design approaches (Recommendation 6); and
- off-ramping capabilities when needed to maintain schedule. (Recommendation 7)

The NASA Administrator should ensure that the NASA Office of the Chief Engineer update NASA acquisition policies to fully implement the following principles throughout development:

- applying iterative design approaches (Recommendation 8); and
- incorporating feedback from users of initial capabilities. (Recommendation 9)

Agency Comments and Our Evaluation

We provided a draft of this report to DOD, DHS, and NASA for review and comment. We received written comments from all three agencies, which are reproduced in appendixes VII through IX and summarized below. DHS and NASA also provided technical comments, which we incorporated as appropriate.

In its written comments, DOD concurred with all four recommendations directed to the agency. DOD noted that it recently updated its acquisition policy tailored for the unique characteristics of the capabilities it acquires, and it stated that it will further consider incorporating the key product development principles in subsequent policy updates.

In its written comments, DHS concurred with all three recommendations directed to the agency. DHS stated that equating and comparing private product development with government acquisition could be confusing given the differing missions – generating a profit versus national security. However, our prior work demonstrates that leading approaches from the private sector can be thoughtfully applied to government acquisition to improve outcomes, even with the differences that exist between commercial product development and government acquisition efforts. Over the last 20 years, agencies, including DHS, have implemented numerous recommendations on the basis of our prior work on leading practices. This greater use of acquisition leading practices by DHS and other agencies has resulted in billions of dollars in aggregate cost avoidance savings and overall improved outcomes.

In its written comments, NASA concurred with both recommendations directed to the agency. At the same time, NASA stated that we should close both recommendations— meaning consider the agency as having already implemented them—based on policies NASA had in place prior to our review. NASA's response could be interpreted in two ways. On the one hand, NASA's response might suggest that the agency agrees with our recommendations but does not know what additional actions it needs to take to fully implement them. In that spirit, we would invite NASA to communicate with GAO—as we follow up with the agency to assess recommendation status or otherwise—about actions NASA could take to be responsive to the recommendations. On the other hand, NASA's response could suggest that while it agrees in principle with our recommendations, it is unconvinced that additional actions are necessary and that its status quo is sufficient. As detailed below, such a view would run contrary to both the findings of our report and the intent of our recommendations.

- With respect to our first recommendation to NASA (Recommendation 8), the agency stated that a complete, iterative design approach is currently documented in its policy. However, NASA's policies do not fully implement the key principle to use an iterative design approach that results in minimum marketable products.
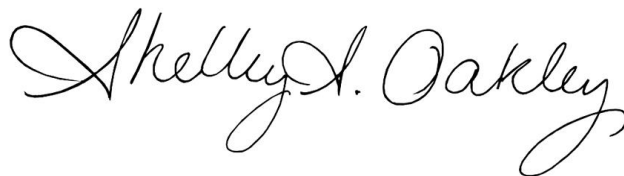
As outlined in our report, NASA policy does not require the use of modern design tools during both hardware and software development or use iterative design and testing to identify a minimum product or initial capability that can inform subsequent efforts. NASA noted that the agency operates in a high-risk environment with a portfolio that consists primarily of unique, one-of-a-kind space flight projects. However, leading companies we interviewed also operate in similar high-risk environments with unique products and successfully use feedback from initial capabilities to inform subsequent efforts.

- Regarding our second recommendation to NASA (Recommendation 9), the agency stated that its policy is dedicated to collection and incorporation of feedback from users throughout the program and project life cycle, including initial capabilities. NASA further noted that stakeholders provide feedback throughout the project life cycle. However, its policies do not fully implement the key principle of collecting customer feedback to inform improvements. Specifically, NASA policies do not require programs to use feedback to identify challenges or to address features to include in subsequent projects.

Consequently, we maintain that NASA has more work to do to implement our two recommendations. We look forward to following up with the agency in the future on new actions it takes to implement them.

We are sending copies of this report to the appropriate congressional committees and offices; the Secretary of Defense; Secretary of Homeland Security; and the NASA Administrator. In addition, the report will be made available at no charge on the GAO website at http://www.gao.gov.

If you or your staff have any questions concerning this report, please contact me at (202) 512-4841 or oakleys@gao.gov. Contact points for our offices of Congressional Relations and Public Affairs may be found on the last page of this report. Staff members making key contributions to this report are listed in appendix X.

Shelby S. Oakley

Director, Contracting and National Security Acquisitions

List of Addressees

The Honorable Maria Cantwell
Chair
The Honorable Roger Wicker
Ranking Member
Committee on Commerce, Science, and Transportation
United States Senate

The Honorable Jon Tester
Chair
The Honorable Richard Shelby
Ranking Member
Subcommittee on Defense
Committee on Appropriations
United States Senate

The Honorable Chris Murphy
Chair
The Honorable Shelley Moore Capito
Ranking Member
Subcommittee on Homeland Security
Committee on Appropriations
United States Senate

The Honorable Adam Smith
Chairman
The Honorable Mike Rogers
Ranking Member
Committee on Armed Services
House of Representatives

The Honorable Bennie G. Thompson
Chairman
Committee on Homeland Security
House of Representatives

The Honorable Lucille Roybal-Allard
Chairwoman
Subcommittee on Homeland Security
Committee on Appropriations
House of Representatives

Appendix I: Prior GAO Reports on Product Development Best Practices

Over the past 20 years, we conducted a series of reviews examining how commercial enterprises manage the development of new products. Table 5 provides an overview of selected prior GAO reports.

Table 5: Selected Prior GAO Reports on Product Development Best Practices

Year, GAO Report	Title	Best Practices Description
1998 GAO/NSAID-98-56	*Best Practices: Successful Application to Weapon Acquisitions Requires Changes in DOD's Environment*	Knowledge on product development can be broken into three points: (1) when a match is made between the customer's requirements and the available technology; (2) when the product's design is determined to be capable of meeting performance requirements; (3) when the product is determined to be producible within cost, schedule, and quality targets.
1999 GAO/NSIAD-99-162	*Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes*	Separating technology development from product development is a best practice. Demonstrating a high level of maturity before allowing new technologies into product development programs puts programs in a better position to succeed.
2000 GAO/NSIAD-00-199	*Best Practices: A More Constructive Test Approach Is Key to Better Weapon System Outcomes*	Leading firms employ testing early to validate and increase product knowledge. Firms validate individual technologies before they are included in a product's design and schedule challenging test events early to expose weaknesses. Knowledge gained is used to improve the product.
2001 GAO-01-288	*Best Practices: Better Matching of Needs and Resources Will Lead to Better Weapon System Outcomes*	Matching requirements and developer resources is critical to program success. Resources include knowledge (technology and capabilities), capacity, time, and money.
2002 GAO-02-701	*Best Practices: Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes*	Activities that enable the capture of design and manufacturing knowledge are critical to supporting increased investment.

Year, GAO Report	Title	Best Practices Description
2003 GAO-03-57	*Best Practices: Setting Requirements Differently Could Reduce Weapon Systems' Total Ownership Costs*	Commercial companies manage total ownership costs—costs to operate and maintain a system in addition to acquisition costs—through activities during product requirements definition and early design. Companies collaborate with customers to derive detailed records on system reliability and the cost of maintenance.
2004 GAO-04-393	*Defense Acquisitions: Stronger Management Practices Are Needed to Improve DOD's Software-Intensive Weapon Acquisitions*	Leading software companies establish an environment that focuses on evolutionary development and continuous improvement, among other things.
2005 GAO-06-110	*Best Practices: Better Support of Weapon System Program Managers Needed to Improve Outcomes*	Corporate leadership provides a strategic foundation, creating conditions for success. Companies generally follow an evolutionary path, rather than attempting to satisfy all needs in a single product development.
2006 GAO-06-883	*Best Practices: Stronger Practices Needed to Improve DOD Technology Transition Processes*	Leading companies use a gated process to manage and oversee technology exploration, development, and transition. Technology transition is bolstered by formal agreements, relationship managers, and metrics.
2007 GAO-07-388	*Best Practices: An Integrated Portfolio Management Approach to Weapon System Investments Could Improve DOD's Acquisition Outcomes*	Portfolio management begins with an enterprise-level identification and definition of market opportunities and then the prioritization of these opportunities within resource constraints.
2008 GAO-08-294	*Best Practices: Increased Focus on Requirements and Oversight Needed to Improve DOD's Acquisition Environment and Weapon System Quality*	Achievable requirements are essential and the systems engineering process ensures that a product's requirements are achievable with available resources.
2009 GAO-09-322	*Best Practices: High Levels of Knowledge at Key Points Differentiate Commercial Shipbuilding from Navy Shipbuilding*	Leading shipbuilders and ship buyers retire risks before a contract is signed; achieve design stability before starting construction; and employ a disciplined construction process with strong buyer oversight, among other things.

Year, GAO Report	Title	Best Practices Description
2010 GAO-10-439	*Best Practices: DOD Can Achieve Better Outcomes by Standardizing the Way Manufacturing Risks Are Managed*	Commercial firms assess producibility at multiple stage gates using clearly defined criteria. Assessments include manufacturing technology and risk, supply chain issues, production facilities and tooling, and materials.
2013 GAO-14-122	*Navy Shipbuilding: Opportunities Exist to Improve Practices Affecting Quality*	Commercial ship buyers employ practices that lead to delivery of ships with minimal deficiencies.
2017 GAO-17-499	*Defense Science and Technology: Adopting Best Practices Can Improve Innovation Investments and Management*	Leading companies group technology development into two portfolios: incremental development, which improves product lines; and disruptive development, which is for riskier innovative and potentially market-shifting technologies.

Source: GAO. | GAO-22-104513

Appendix II: Objectives, Scope, and Methodology

This report assesses (1) how selected leading companies structure and organize product development activities, and (2) the extent to which Department of Defense (DOD), Department of Homeland Security (DHS), and National Aeronautics and Space Administration (NASA) department-wide and primary policies for major acquisitions incorporate key principles that leading companies rely on for successful product development.

To identify the structure and organization of leading company product development activities, we conducted semi-structured interviews with senior management and other representatives knowledgeable about product development from 13 leading companies across a variety of product development sectors. In particular, we discussed their (1) organizational structure for product development, and (2) key product development phases and activities, including the key activities that guide product development efforts. We selected these companies because they received rankings as leaders in well-recognized lists and are recognized as successfully being innovative or having disruptive approaches to product development. In addition, these companies are generally financially successful and well-established, demonstrated by an investment-grade long-term credit rating from Standard and Poor's Global Ratings in the case of public companies.

We researched awards to commercial companies for excellence in performance, business achievements, and innovation, as well as lists that reflect top companies based on innovation and financial performance metrics. The key awards and lists we identified include:

- Business Intelligence Group (BIG) Innovation Awards
- Boston Consulting Group's Most Innovative Companies
- MIT Technology Review's 50 Smartest Companies
- PwC's Strategy& Global Innovation 1000 study
- Thomson Reuters' Top 100 Global Technology Leaders
- Worldwide Boat's America's 10 Best Yacht Builders
- YachtWorld's 10 Top Luxury Yacht Builders

We analyzed the responses from the company leaders and subject matter experts and analyzed available company documentation, and we organized their statements and information by common themes. We developed company summaries based on our

interviews with company representatives that we used to identify key activities and principles leading companies used to structure and organize their product development approaches.

To validate our analysis, we shared the company summaries with company representatives and solicited their feedback. We further validated our analysis with members of GAO's Polaris Council. The Polaris Council is a group of exceptional science, technology, and policy leaders and experts from many fields, established to advise GAO on emerging science and technology issues facing Congress. Finally, we presented our analysis of these key activities and principles to senior officials within DOD, DHS, and NASA. The following companies are included in our review:

- Amazon sells products online and in person from businesses worldwide, as well as its own products. It also designs and engineers various types of consumer electronics, and offers cloud-based technology services including computing, storage, databases, and analytics. Amazon was recently recognized in the Boston Consulting Group's list of Most Innovative Companies, the MIT Technology Review's 50 Smartest Companies, PwC's Strategy& Global Innovation 1000 study, and Thomson Reuters' Top 100 Global Technology Leaders.

- Carnival Corporation operates a large portfolio of global cruise lines and is a leading buyer of commercial ships. It recently received multiple industry and consumer awards for best cruise line, including in USA Today's 10Best Awards and Travel Weekly Readers' Choice Awards.

- Derecktor Shipyards, Inc. constructs, repairs, and refits a wide range of custom sailing and motor yachts and commercial vessels. Derecktor was recently included in Yachtworld's 10 Top Luxury Yacht Builders and in Worldwide Boat's America's 10 Best Yacht Builders.

- GE Renewable Energy engineers wind, solar, and hydropower energy products and provides grid infrastructure and technologies to customers around the world. GE was recently recognized in PwC's Strategy& Global Innovation 1000 study and in the MIT Technology Review's 50 Smartest Companies.

- Gulfstream Aerospace Corporation designs, builds, and maintains business jet aircraft for corporate, government, and private customers around the world. Gulfstream recently received the BIG Innovation Award for its G500 aircraft.

- IBM provides a range of integrated technologies including cloud computing, artificial intelligence, information technology infrastructure, data analytics, and cybersecurity. IBM recently received the BIG Innovation Award for its Cognos Analytics product and was recognized in the Boston Consulting Group's list of Most Innovative Companies, the MIT Technology Review's 50 Smartest Companies, PwC's Strategy& Global Innovation 1000 study, and Thomson Reuters' Top 100 Global Technology Leaders.

- Kiewit Corporation is one of the largest engineering and construction firms in North America. Kiewit offers engineering and construction services in a variety of markets

including transportation; oil, gas, and chemical; power; building; water/wastewater; industrial; and mining. Kiewit has been repeatedly ranked by Engineering News-Record in the list of top contractors and designers.

- Merck is a biopharmaceutical company that researches and develops products for human and animal health, offering pharmaceutical products in the areas of oncology, vaccines, infectious diseases, and cardio-metabolic disorders. Merck was recently recognized in the MIT Technology Review's 50 Smartest Companies and PwC's Strategy& Global Innovation 1000 study.

- Planet is a provider of global, daily satellite imagery and geospatial solutions. Planet designs, builds, and operates Earth observation imaging satellites, and provides data, insights, and software solutions to agriculture, forestry, intelligence, education, and finance industries and government agencies.

- Qualcomm develops breakthrough technologies in computing and communication. Qualcomm was recently recognized in PwC's Strategy& Global Innovation 1000 study and Thomson Reuters' Top 100 Global Technology Leaders.

- Siemens offers a wide range of technology products for buildings and infrastructure, transportation, energy and healthcare, among others. It manufactures hardware, such as electric motors and generators, as well as develops software and technologies to digitalize and automate the product development life cycle. Siemens was recently recognized in Boston Consulting Group's list of Most Innovative Companies and PwC's Strategy& Global Innovation 1000 study.

- Space Exploration Technologies Corporation (SpaceX) designs, manufactures, and launches advanced rockets and spacecraft. It offers a family of launch vehicles that provide access to space for commercial, government, and international customers. SpaceX was recently recognized in the MIT Technology Review's 50 Smartest Companies.

- Virgin Orbit provides launch services for commercial and government satellites. Virgin Orbit was recently recognized in the Frost and Sullivan Manufacturing Leadership Awards.

To determine the extent to which DOD, DHS, and NASA policies for major acquisitions reflect key principles of leading companies and result in similar outcomes, we reviewed the current, primary department-wide acquisition policies at DOD, DHS, and NASA, which are detailed below. We then compared agency acquisition policies with the key principles that guide product development activities in leading companies to identify similarities and differences. For each sub-principle, we identified key terms that best represented a translation of terms from the leading practices sub-principles into language in the government policy documents. We reviewed each government policy and assessed whether any language in the policies implemented the key principles. We documented this analysis and then performed word searches of each of those key terms in the policy documents identified below for each agency to confirm that analysis. Based on whether the applicable text demonstrated that the policy document addressed the

sub-principle, we scored each sub-principle as Fully Implemented, Partially Implemented, or Not Implemented.

For DOD, the department-wide management principles that govern the defense acquisition system are described in the following policies:

- DOD Directive 5000.01,

- DOD Instruction 5000.02, and

- Joint Capabilities Integration and Development System Manual.

We first reviewed these department-wide policies to determine the extent to which they implement the sub-principles we identified from our analysis of leading company practices. Additionally, we reviewed the individual policies that govern the primary acquisition pathways we review in our annual weapon system assessments. These policies include:

- DOD Instruction 5000.80 Middle Tier of Acquisition,

- DOD Instruction 5000.85 Major Capability Acquisition, and

- DOD Instruction 5000.87 Software Acquisition.

We also reviewed relevant DOD functional policies. These policies include:

- DOD Instruction 5000.73 Cost Analysis Guidance and Procedures,

- DOD Instruction 5000.82 Acquisition of Information Technology,

- DOD Instruction 5000.84 Analysis of Alternatives,

- DOD Instruction 5000.86 Acquisition Intelligence,

- DOD Instruction 5000.88 Engineering of Defense Systems,

- DOD Instruction 5000.89 Test and Evaluation,

- DOD Instruction 5000.90 Cybersecurity for Acquisition, and

- DOD Instruction 5000.91 Product Support Management for the Adaptive Acquisition Framework.

Though language reflecting a given sub-principle may be found in multiple documents, we did not include all possible instances of such language. Rather, we pulled illustrative quotes from one or two documents as appropriate to demonstrate where DOD policies appeared to meet the intent of the sub-principle. We did not include the policies listed below, as they fell outside the scope of our review. Specifically, we did not include DOD policies for pathways not included in our annual weapon assessments or that generally precede or follow the agency's system development and production activities, which we found correspond to leading companies' product development activities. Among the policies we excluded were:

- DOD Directive 5000.71 Rapid Fulfillment of Urgent Operational Needs,

- DOD Instruction 5000.74 Acquisition of Services,

- DOD Instruction 5000.75 Defense Business Systems,

- DOD Instruction 5000.81 Urgent Capability Acquisition,

- DOD Instruction 5000.83 Technology and Program Protection, and

- DOD Instruction 5010.44 Intellectual Property.

For DHS, the acquisition management principles are described in DHS Acquisition Management Directive 102-01. We first reviewed this department-wide policy to determine the extent to which it implements the sub-principles we identified from our analysis of leading company principles. If the policy language in this directive did not reflect key terms within a sub-principle, we looked at related policy directives and implementing instructions that outline acquisition management expectations in greater detail. These included:

- DHS Instruction 102-01-001 Acquisition Management Instruction,

- DHS Instruction 102-01-103 Systems Engineering Life Cycle,

- DHS Instruction 102-01-004 Agile Methodology for Software Development and Delivery for Information Technology,

- DHS Instruction Manual 102-01-004-01 Agile Development and Delivery for Information Technology Instruction Manual,

- DHS Instruction 102-01-006 Acquisition Program Management Staffing,

- DHS Directive 026-06 Test and Evaluation,

- DHS Instruction 026-06-001 Test and Evaluation,

- DHS Directive 107-01 Joint Requirements Integration and Management System, and

- DHS Instruction Manual 107-01-001-01 Department of Homeland Security Manual for the Operation of the Joint Requirements Integration and Management System.

We did not include DHS guidebooks, or other documents that generally are non-mandatory. We also did not include the policies listed below, as they fell outside the scope of this review. Specifically, we did not include DHS policies that do not reflect standard processes for developing major acquisition programs or that generally precede or follow the agency's system development and production activities, which we found correspond to leading companies' product development activities. Among the policies we excluded were:

- DHS Instruction 102-01-011 Rapid Acquisition, and

- DHS Instruction 102-01-007 Post Full Operating Capability Operational Activity Instruction.

For NASA, the department-wide management principles are found in the following NASA Policy Directives:

- NASA Policy Directive 1000.0C NASA Governance and Strategic Management Handbook,
- NASA Policy Directive 1000.3E The NASA Organization w/Change 85,
- NASA Policy Directive 1000.5C Policy for NASA Acquisition,
- NASA Policy Directive 7120.4E NASA Engineering and Program/Project Management Policy, and
- NASA Policy Directive 7120.6A Knowledge Policy for Programs and Projects.

We first reviewed these department-wide policies to determine the extent to which they implement the sub-principles we identified from our analysis of leading company principles. If the policy language in these directives did not reflect key terms within a sub-principle, we reviewed NASA Procedural Requirements that outline acquisition management expectations in greater detail. These included the following:

- NASA Procedural Requirements 7120.5F NASA Space Flight Program and Project Management Requirements,
- NASA Procedural Requirements 7123.1C NASA Systems Engineering Processes and Requirements (w/Change 1),
- NASA Procedural Requirements 7120.7A Information Technology Program and Project Management Requirements,
- NASA Procedural Requirements 7150.2C Software Engineering Requirements,
- NASA Procedural Requirements 8735.2C Hardware Quality Assurance Program Requirements for Programs and Projects (updated with Change 1), and
- NASA/SP-2014-3705 Space Flight Program and Project Management Handbook.

We did not review the policies listed below, as they fell outside the scope of this review. Specifically, we excluded NASA policies for basic and applied research and advanced technology development. These policies cover activities that generally precede and follow the agency's system development and production activities, which we found correspond to leading companies' product development activities. Among the policies excluded were:

- NASA Procedural Requirements 7120.10A Technical Standards for NASA Programs and Projects, and
- NASA Procedural Requirements 7120.8A Research and Technology Program and Project Management.

We interviewed senior acquisition officials from each agency to better understand key acquisition processes and pathways outlined in the aforementioned policies and how those function in practice. We met with officials from those offices multiple times in order to obtain feedback on the key principles we identified from leading companies, as well as our analysis of agency policy documents. The first round of interviews established the key principles and provided agency officials the opportunity to provide feedback on how those principles align with agency policies. The second round of interviews focused on our preliminary analysis of the policy documents and any feedback the agency officials had regarding that analysis. We also reviewed and summarized our prior work on acquisition programs, performance, and culture within DOD, DHS, and NASA.

We conducted this performance audit from August 2020 to March 2022 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix III: Department of Defense Policy Analysis

Figure 11: Department of Defense (DOD) Policies Reflect Some Key Business Case and Iterative Design Product Development Sub-Principles

Department of Defense

Principle 1: Attain a sound business case that is informed by research along with collaboration with customers

Sub-principles

1) Invest time to research a marketable product.

2) Solicit early feedback from customers for both hardware and software development.

3) Develop cost, schedule, and performance tenets, or parameters, to define project goals before allocating initial funding.

4) Preserve institutional memory and share corporate knowledge in order to develop initial estimates, avoid earlier mistakes, and build on previous success.

5) Continuously evaluate cost, schedule, and performance parameters to ensure a high level of confidence in the project team's ability to deliver the product within cost and schedule targets prior to committing to a public release date.

6) Employ right-sized teams that have sufficient experience and autonomy to develop the product.

7) Willing to end product development if the product no longer has a sound business case.

Principle 2: Use an iterative design approach that results in minimum marketable products

Sub-principles

1) Use modern design tools during both hardware and software development that enable multiple design iterations.

2) Use elements of Agile development methodologies that promote iteration in both hardware and software product development.

3) Use iterative design and testing to identify a minimum marketable product that can be followed by successive updates for both hardware and software development.

Key principles

☐ Agency policies do not implement the majority of the sub-principles in the key principle

▰ Agency policies partially implement the majority of the sub-principles in the key principle

▰ Agency policies fully implement all of the sub-principles in the key principle

Sub-principles

☐ Agency policies do not implement the sub-principle

▰ Agency policies either partially implement the sub-principle or only apply to a subset of acquisition programs

▰ Agency policies fully implement the sub-principle for all acquisition program types

Source: GAO analysis of DOD data. | GAO-22-104513

Text of Figure 11: Department of Defense (DOD) Policies Reflect Some Key Business Case and Iterative Design Product Development Sub-Principles

Principle 1: Attain a sound business case that is informed by research along with collaboration with customers. (Agency policies partially implement the majority of the sub-principles in the key principle)

1. Invest time to research a marketable product. (Agency policies either partially implement the sub-principle or only apply to a subset of acquisition programs).

2. Solicit early feedback from customers for both hardware and software development. (Agency policies partially implement the majority of the sub-principles in the key principle)

3. Develop cost, schedule, and performance tenets, or parameters, to define project goals before allocating initial funding. . (Agency policies either partially implement the sub-principle or only apply to a subset of acquisition programs).

4. Preserve institutional memory and share corporate knowledge in order to develop initial estimates, avoid earlier mistakes, and build on previous success. . (Agency policies either partially implement the sub-principle or only apply to a subset of acquisition programs).

5. Continuously evaluate cost, schedule, and performance parameters to ensure a high level of confidence in the project team's ability to deliver the product within cost and schedule targets prior to committing to a public release date. . (Agency policies either partially implement the sub-principle or only apply to a subset of acquisition programs).

6. Employ right-sized teams that have sufficient experience and autonomy to develop the product. . (Agency policies either partially implement the sub-principle or only apply to a subset of acquisition programs).

7. Willing to end product development if the product no longer has a sound business case. . (Agency policies either partially implement the sub-principle or only apply to a subset of acquisition programs).

Principle 2: Use an iterative design approach that results in minimum marketable products. (Agency policies partially implement the majority of the sub-principles in the key principle)

1. Use modern design tools during both hardware and software development that enable multiple design iterations. . (Agency policies either partially implement the sub-principle or only apply to a subset of acquisition programs).

2. Use elements of Agile development methodologies that promote iteration in both hardware and software product development. . (Agency policies either partially implement the sub-principle or only apply to a subset of acquisition programs).

3. Use iterative design and testing to identify a minimum marketable product that can be followed by successive updates for both hardware and software development. . (Agency policies either partially implement the sub-principle or only apply to a subset of acquisition programs).

Source: GAO analysis of DOD data. | GAO-22-104513

Figure 12: Department of Defense (DOD) Policies Reflect Some Schedule and Customer Feedback Key Product Development Sub-Principles

Source: GAO analysis of DOD data. | GAO-22-104513

Text of Figure 12: Department of Defense (DOD) Policies Reflect Some Schedule and Customer Feedback Key Product Development Sub-Principles

Principle 3: Prioritize schedule by off-ramping capabilities when necessary. (Agency policies partially implement the majority of the sub-principles in the key principle)

1. Use periodic reviews throughout the product development process to monitor project performance, and take steps to ensure development remains on course. (Agency policies either partially implement the sub-principle or only apply to a subset of acquisition programs)

2. Maintain a realistic assessment of product development activities, with a willingness to make difficult decisions about capabilities. (Agency policies either partially implement the sub-principle or only apply to a subset of acquisition programs)

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3. Off-ramp capabilities that present a risk to delivering the product on schedule. (Agency policies either partially implement the sub-principle or only apply to a subset of acquisition programs)

Principle 4: Collect customer feedback to inform improvements to the minimum marketable product. (Agency policies partially implement the majority of the sub-principles in the key principle)

1. Establish a process to facilitate ongoing engagement with customers after product release. (Agency policies either partially implement the sub-principle or only apply to a subset of acquisition programs)

2. Use customer feedback to identify challenges to address and new features to include in subsequent releases. (Agency policies either partially implement the sub-principle or only apply to a subset of acquisition programs)

Source: GAO analysis of DOD data. | GAO-22-104513
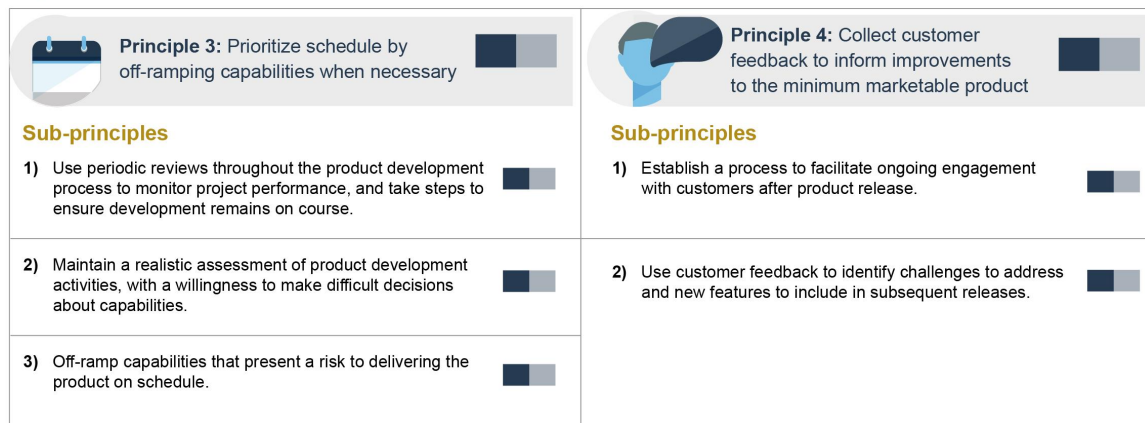
Principle 1: Attain a Sound Business Case that Is Informed by Research along with Collaboration with Customers

Invest Time to Research a Marketable Product

Leading companies utilize various methods to determine whether there is a market for a proposed product. We reviewed policies for provisions that require programs and projects to be credible and achievable, and to be based on validated needs.[42] We found that Department of Defense (DOD) policies fully implement this sub-principle by generally requiring that all acquisition programs consider required needs for a product or conduct an early analysis of alternatives to determine what product would achieve a required need. For example, DOD's Directive 5000.01 establishes that the Under Secretary of Defense for Research and Engineering is responsible for confirming that a materiel solution that addresses a validated need or capability for a major defense acquisition program is technically feasible and achievable.[43] Additionally, DOD Instruction 5000.02 states that the various pathways in the Adaptive Acquisition Framework (AAF) "provide opportunities for [program officials] to develop acquisition strategies and employ acquisition processes that match the characteristics of the capability being acquired."[44] DOD Instruction 5000.02 also establishes that the Under Secretary of Defense for Research and Engineering is responsible for "confirm[ing] that a materiel solution that addresses the validated need or capability gap for a major defense acquisition program (MDAP) is technically feasible and achievable." The Joint

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[42]We analyzed the DOD's department-wide acquisition policies and the primary instructions governing the adaptive acquisition framework: Department of Defense Directive 5000.01, *The Defense Acquisition System;* DOD Instruction 5000.02, *Operation of the Adaptive Acquisition Framework;* the Joint Capabilities Integration and Development Systems Manual; DOD Instruction 5000.73, *Cost Analysis Guidance and Procedures;* DOD Instruction 5000.80, *Operation of the Middle Tier of Acquisition (MTA);* DOD Instruction 5000.82, *Acquisition of Information Technology*; DOD Instruction 5000.84, *Analysis of Alternatives;* DOD Instruction 5000.85, *Major Capability Acquisition;* DOD Instruction 5000.86, *Acquisition Intelligence;* DOD Instruction 5000.87, *Operation of the Software Acquisition Pathway;* DOD Instruction 5000.88, *Engineering of Defense Systems;* DOD Instruction 5000.89, *Test and Evaluation;* DOD Instruction 5000.90, *Cybersecurity for Acquisition*; and DOD Instruction 5000.91, *Product Support Management for the Adaptive Acquisition Framework.*

[43]DOD Directive 5000.01, *The Defense Acquisition System* (Sept. 9, 2020).

[44]DOD Instruction 5000.02, *Operation of the Adaptive Acquisition Framework* (Jan. 23, 2020).

Capabilities Integration and Development System (JCIDS) contemplates the review and validation of a proposed capability gap.

Solicit Early Feedback from Customers for Both Hardware and Software Development

Obtaining feedback from new and existing customers for a potential product is an important aspect to attaining a sound business case for leading companies. We reviewed policies for provisions that require stakeholder or end-user involvement in early program planning stages. We found that DOD policies partially implement this sub-principle by requiring software acquisition programs to solicit feedback from end users. DOD Instruction 5000.87, which we will refer to as the software policy moving forward, defines end users as those who will ultimately use the software solution. Within the software policy, end users convey operational concepts, requirements, and needs; participate in continuous testing activities; and provide feedback on developed capabilities.[45] While DOD Instruction 5000.02 also refers to using small teams that include end users, this policy's reference to small teams is within a description of the software policy.[46] The application of the software policy is limited to software acquisitions.

Policies governing other acquisitions, including DOD Instruction 5000.85, the major capability pathway policy, do not establish early user feedback as a requirement for developing a sound business case. The major capability policy does establish that programs can conduct "limited user tests to provide initial assessments of operational effectiveness." However, this limited testing occurs after the program has already started developing a product and is well past the planning stages of a program.[47] DOD's Testing and Evaluation policy includes similar language, focused on requesting user feedback during the testing phase of an acquisition program.[48]

Develop Cost, Schedule, and Performance Parameters

Leading companies define the goals of the product under development using cost, schedule, and performance tenets, or parameters, before allocating initial funding to the product development project. We reviewed policies for provisions that require development of cost, schedule, and performance requirements or parameters in early program planning stages. We found that DOD acquisition policies we reviewed fully

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[45]DOD Instruction 5000.87, *Operation of the Software Acquisition Pathway* (Oct. 2, 2020).

[46]DOD Instruction 5000.02.

[47]DOD Instruction 5000.85, *Major Capability Acquisition* (Aug. 6, 2020).

[48]DOD Instruction 5000.89, *Test and Evaluation* (Nov. 19, 2020).

implement this sub-principle through department-wide acquisition policy. DOD Directive 5000.01, which applies to all AAF pathways, requires that program goals for cost, schedule, and performance parameters (or alternative quantitative management controls) describe the program over its life cycle and approved program baseline parameters will serve as control objectives.[49] Similarly, the major capability pathway policy requires that program officials for major defense acquisition programs approve the goals for cost, schedule, and performance, and document the decision in a program goals approval memorandum.[50] The policy states that for these programs, the milestone decision authority must approve the goals before funds are obligated for technology development, systems development, or production. The initial goals will inform the acquisition program's initiation.[51]

Preserve Institutional Memory and Share Corporate Knowledge

Leading companies in our review have established processes—formal and informal—for preserving institutional memory and sharing corporate knowledge. We reviewed policies for provisions that require documenting and sharing knowledge or lessons learned to develop initial goals or plans. We found that DOD's policies partially implement this sub-principle. The department's policies only require that programs share knowledge or implement lessons learned in a very limited capacity. DOD's Acquisition of Information Technology policy, for example, includes a requirement for post-implementation reviews, but those reviews are limited to the information technology (IT) aspects of the program, not the program as a whole. Additionally, DOD's Test and Evaluation policy requires the establishment of "a common set of data for each major weapon system type to be collected on damage incurred during combat operations….The lessons learned from analyzing these data will be included, as appropriate, in both the capability requirements process and the acquisition process for new acquisitions, modifications, and upgrades."[52]

DOD officials noted that the middle-tier acquisition (MTA) policy requires programs to provide entrance and exit documentation in a shared database, and that Defense Acquisition University maintains a companion guide website listed in the MTA policy with updates and lessons learned for the pathway. However, none of the policies require using institutional memory or sharing knowledge among programs to determine the best path forward for acquisition programs in order to achieve success. Applying lessons

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[49]DOD Directive 5000.01.

[50]DOD Directive 5000.01.

[51]DOD Instruction 5000.85.

[52]DOD Instruction 5000.89.

learned from combat damage has limited applications, as it does not address lessons learned during an acquisition process.

DOD officials told us that the policy documents do not require collecting lessons learned because those events occur at a lower level than department-wide acquisition policy. Officials said that DOD has many communities of practice dedicated to gathering lessons learned and that this is a focus for the broader DOD acquisition community. For example, officials said the agency distributes videos and vignettes on lessons learned across programs, so that other acquisition officials can take those lessons and apply them to their own programs. Additionally, acquisition officials said that the acquisition policies themselves resulted from lessons learned, and that the acquisition community has guidebooks based on lessons learned from previous programs.

Evaluate Cost, Schedule, and Performance Parameters Continuously

In addition to ensuring project teams can deliver products within cost and schedule targets, leading companies in our review continuously evaluate cost, schedule, and performance parameters before making a commitment to a public release date. We reviewed policies for provisions that require a high confidence level in cost and schedule estimates and for programs to reevaluate, update, or mature these estimates if needed prior to program commitment. We found that DOD policies partially implement this sub-principle through requirements in specific pathway policies, but these policies are limited in scope and do not apply consistently across DOD acquisition programs. Neither DOD Directive 5000.01 nor DOD Instruction 5000.02 includes requirements to evaluate parameters continuously in order to ensure a program's ability to deliver the product within cost, such as through confidence levels or updating estimates as necessary prior to product commitment.

However, certain policies do require that program officials make adjustments and update their goals as necessary as the program progresses. The major capabilities policy requires that acquisition, requirements, and budgeting are closely related and must operate simultaneously in close coordination.[53] The policy outlines that programs in this pathway may have to make adjustments during a program's life cycle to keep the three processes aligned to ensure programs are executable and in order to adapt to evolving circumstances. Additionally, this policy requires, based on statute, that the milestone decision authority for a major defense acquisition program determine with a high degree of confidence that the technology developed within a program will not delay the fielding target of the program.[54] If the milestone decision authority determines that a technology related to a major system component will delay the program, that technology must be

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[53]DOD Instruction 5000.85.

[54]10 U.S.C. § 4251(b)(8) (2022).

sufficiently matured and demonstrated in a relevant environment separate from the program, and there must be an effective plan for adoption or insertion by the relevant program.[55]

Along with the major capability policy, the software policy requires programs to develop and track a set of metrics to assess and manage the performance, progress, speed, cybersecurity, and quality of the software development, its development teams, and ability to meet users' needs.[56] The policy further states that these software acquisition programs will continue to update their cost estimates and cost and software data reporting from the planning phase throughout the execution phase.

DOD acquisition officials acknowledged the fact that other policies could include language similar to the major capability and software pathways. DOD officials also cited independent cost estimates as tools they use to establish reasonable confidence for some programs.

Employ Right-Sized Teams

Leading companies in our review focus on ensuring they have the right project team with sufficient experience and autonomy for their product development project. We reviewed policies for provisions that require program plans to include staffing plans or an outline of key or necessary personnel that address authority and responsibility, and descriptions of teams being experienced, empowered, or having autonomy in assigned duties. We found that DOD's policies partially implement this sub-principle. DOD's software policy requires programs to use small, empowered teams and to scale larger efforts across multiple teams.[57]

However, this policy is only required of programs using this specific pathway. DOD Directive 5000.01 does require that program officials have sufficient authority to carry out programs, but this requirement does not address the appropriate level of staffing to accomplish a program's objectives. Rather, DOD Directive 5000.01 states that program managers have "sufficient authority to accomplish approved program objectives for development, production, product support, and sustainment."[58] The Product Support Management policy also requires that the program support manager "establish a cross-functional team of subject matter experts to develop accurate assumptions, capture

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[55]Statutory requirements for Milestone A and Milestone B approvals are codified at 10 U.S.C. §§ 4251 and 4252 and reflected in the major capability policy. DOD Instruction 5000.85.

[56]DOD Instruction 5000.87.

[57]DOD Instruction 5000.87.

[58]DOD Directive 5000.01.

data, and perform data analysis to develop and refine the product support analysis, also referred to as the supportability analysis."[59] While this does establish an empowered team, the focus of this team is limited to product support solutions.

End Product Development If Needed

Rather than continue to invest time and resources, leading companies in our review will end product development if the product no longer has a sound business case. We reviewed policies for provisions that require programs to consider resource allocation or termination if the program no longer provides value, fails to stay within parameters, or in the case of a cost or schedule breach. We found that DOD policies partially implement this sub-principle. Specifically, DOD Instruction 5000.02 and DOD Directive 5000.01 do not refer to terminating programs when the program no longer provides value. Several pathway policies require programs to consider resource reallocation or termination if the program no longer provides value or fulfills requirements.

For example, the software policy requires that stakeholders perform annual value assessments on delivered software and provide feedback on whether the software capabilities are timely and worth the investment. The program authorities can then make program decisions based on the outcome of that feedback.[60] The Acquisition of IT policy also requires programs to consider the program's effectiveness and whether termination of the IT systems is necessary to meet mission requirements.[61]

The major capability policy states that the military service chiefs assist the Secretary of the Military Department concerned with functions that include termination of development or procurement programs for which life-cycle cost, schedule, and performance expectations are no longer consistent with approved military requirements and levels of priority, or which no longer have approved military requirements.[62] However, the MTA policy, which also provides opportunities for programs to transition out of the pathway, does not specify this transition would occur due to cost, schedule, or performance expectations that are no longer consistent with the program's business case.[63] While a DOD policy provides that MTA programs generally may not exceed a 5-

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[59]DOD Instruction 5000.91.

[60]DOD Instruction 5000.87.

[61]DOD Instruction 5000.82, *Acquisition of Information Technology* (Apr. 21, 2020).

[62]DOD Instruction 5000.85.

[63]DOD Instruction 5000.80, *Operation of the Middle Tier of Acquisition (MTA)* (Dec. 30, 2019).

year time frame, there is no consequence if those programs do not meet that time frame.[64]

DOD officials noted that certain statutory requirements known as Nunn-McCurdy require the department to report to Congress whenever a major defense acquisition program experiences cost growth that exceeds certain thresholds.[65] While these breach requirements do involve termination of programs as a potential option, the statute is limited to major defense acquisition programs (associated with the major capability acquisition pathway) and designated major defense subprograms.

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[64]DOD Instruction 5000.80.

[65]10 U.S.C. § 4371-4377 (2022). There are a number of statutory provisions that help implement cost growth reporting under Nunn-McCurdy. Nunn-McCurdy breach occurs when a program unit cost exceeds certain thresholds. When that happens, DOD must notify Congress of the breach. There are two types of Nunn-McCurdy breaches: significant breaches and critical breaches. A breach of the significant cost growth threshold occurs when the program acquisition unit cost or the procurement unit cost increases by at least 15 percent over the current baseline estimate or at least 30 percent over the original baseline estimate. A breach of the critical cost growth threshold occurs when the program acquisition unit cost or the procurement unit cost increases by at least 25 percent over the current baseline estimate or at least 50 percent over the original baseline estimate.

Principle 2: Use an Iterative Design Approach that Results in Minimum Marketable Products

<u>Use of Modern Design Tools</u>

Leading companies in our review use modern design tools, such as digital engineering and additive manufacturing, throughout development for both hardware and software. We reviewed policies for provisions that require government and contractor software and hardware teams to use modern design tools or digital engineering to iterate on design. We found that DOD policies partially implement this sub-principle. DOD Directive 5000.01 does require that managers at every level consider and adopt innovative practices, including leading commercial practices and electronic business solutions, that reduce cycle time and cost, and encourage teamwork.[66] This requirement for innovative practices is not, however, linked to the ability to iterate on design.

Similarly, the MTA policy provides for the use of innovative technologies to rapidly develop fieldable prototypes to demonstrate new capabilities and meet emerging military needs.[67] However, the reference to innovative technologies does not specifically address design tools for product development. The software policy requires government and contractor software teams to use modern tools and techniques, and human-centered design processes to iteratively deliver software to meet the users' priority needs.[68] However, this policy is limited to software applications. The Test and Evaluation policy references use of a digital engineering strategy, but it is limited to the testing and evaluation phase of a product.[69] The Engineering of Defense Systems Instruction also

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[66]DOD Instruction 5000.01.

[67]DOD Instruction 5000.80.

[68]DOD Instruction 5000.87.

[69]DOD Instruction 5000.89.

requires a digital plan to be accessible across the life cycle of the program, but this is only applicable to MDAP programs and specific acquisition categories.[70]

Use Elements of Agile Development Methodologies

Leading companies in our review use Agile development methodologies to promote iteration in both hardware and software product development. We reviewed policies for provisions that require modern iterative development or adaptive development methodologies (e.g., Agile) that promote iteration in development for both hardware and software. We found that DOD policies partially implement this sub-principle. The software policy states that programs will require government and contractor software teams to use "modern iterative software development methodologies (e.g., agile or lean)…to iteratively deliver software to meet the users' priority needs."[71] DOD Instruction 5000.02 also includes language regarding the use of Agile software development, but only within a description of the characteristics of the software policy.[72] The Engineering of Defense Systems policy requires that program managers use the appropriate software development approach, and it states that program managers should consider an iterative software development process using Agile development methods. The Product Support policy requires use of Agile processes for MTA programs, which contain elements of both hardware and software.

DOD officials said that the AAF is meant to promote policies being used in conjunction with one another in order to achieve the best result for acquisition programs. However, there is no specific requirement for DOD programs to use other pathways to achieve those best results, and DOD officials acknowledged that there is no requirement to use Agile development for hardware.

Use Iterative Design and Testing to Identify a Minimum Marketable Product

Leading companies in our review use iterative design and testing to identify a minimum marketable product that can be followed by successive updates to that product. We reviewed policies for provisions requiring development of a minimum viable product or initial capability to be improved by subsequent or evolving releases. We found that DOD policies partially implement this sub-principle. DOD Directive 5000.01 refers to how "approved, time-phased capability needs, matched with available technology and

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[70]DOD Instruction 5000.88, *Engineering of Defense Systems* (Nov. 18, 2020). The policy pertains to MDAPs; Acquisition Category II programs—major systems estimated by the DOD component head to require an eventual total expenditure for research, development, and test and evaluation of more than $200 million in fiscal year 2020 constant dollars, or for procurement of more than $920 million in fiscal year 2020 constant dollars; and Acquisition Category III programs—programs that are not designated a major system by the milestone decision authority.

[71]DOD Instruction 5000.87.

[72]DOD Directive 5000.02.

resources, will enable incremental acquisition strategies and continuous capability improvement."[73] This directive implies iterative design followed by successive updates, but there is no reference to a minimum product prior to developing successive updates.

By comparison, the software policy requires program officials to "use an iterative, human-centered design process to define the minimum viable product (MVP) recognizing that an MVP's definition may evolve as user needs become better understood."[74] The software policy is limited to software efforts using the software pathway and does not include hardware acquisitions or programs using other pathways. There are references in the major capabilities policy to modular design "to evolve systems capability," but this policy also does not refer to using modular design to identify a minimum product.[75]

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[73]DOD Instruction 5000.01.

[74]DOD Instruction 5000.87.

[75]DOD Instruction 5000.85.

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Principle 3: Prioritize Schedule by Off-Ramping Capabilities when Necessary

<u>Conduct Oversight through Periodic Reviews</u>

Leading companies in our review conduct periodic reviews throughout the product development process to monitor project performance and to take steps to ensure development remains on course. We reviewed policies for provisions that require milestones or decision events that include reviews of product development progress or deviation to determine whether the program can proceed with planned development activities. We found that DOD policies partially address this sub-principle. DOD Directive 5000.01 requires that programs establish program parameters, and then document, record, and report any deviations from those baseline parameters. While this policy language demonstrates a process for monitoring program performance throughout the acquisition process, the policy does not require programs to take steps to correct these deviations in order to deliver the required capabilities after they report those deviations.

DOD officials noted that MDAPs trigger statutory cost and schedule breaches if they experience cost or schedule growth that exceeds certain thresholds. However, these requirements are specific to MDAPs and designated subprograms, and do not apply to programs using other pathways, such as the MTA or software pathways.

<u>Maintain a Realistic Assessment of Product Development Activities</u>

Leading companies in our review focus on realism—what can be achieved—rather than optimism—what is hoped to be achieved. As a result, these leading companies are willing to make difficult decisions about capabilities. We reviewed policies for provisions that require proven or objective processes for reviews to evaluate product development activities, and permit higher-level officials to redirect programs or make trade-offs in the event of a problem. We found that DOD policies partially address this sub-principle. Individual pathway policies require proven or objective processes for reviews and allow program officials to make trade-offs in the event of issues. DOD Instruction 5000.02, a department-wide policy, does include language that could potentially address this principle but that requirement lacks specificity. For example, the policy requires the Program Executive Officer to balance the risk, cost, schedule, performance, interoperability, sustainability, and affordability of a portfolio of acquisition programs and

to deliver an integrated suite of mission effective capability to users.[76] While balancing these different factors may qualify as trade-offs, this policy requirement relates to an entire portfolio of programs, rather than trade-offs with a single program's acquisition process.

Further, DOD Instruction 5000.02 requires program officials to develop engineering plans and processes applicable to the pathways to mature technology, conduct necessary systems engineering trade-offs, and produce and manage appropriate technical baselines through the use of systems engineering technical reviews.[77] These trade-offs are related specifically to systems engineering, not to the acquisition process, so this requirement also does not address maintaining a realistic assessment of the program. The software policy does require program officials to make investment decisions and balance different program factors when making those decisions, albeit in a limited capacity for software development. DOD officials are required to "allocate resources to the most relevant capability needs, [and] make software acquisition and development investment decisions within a framework that addresses trade-offs between capabilities, affordability, risk tolerance, and other considerations."[78] The major capability policy also addresses difficult decisions about capabilities. Specifically, it includes responsibilities for decision makers to balance "resources against priorities and ensure appropriate trade-offs are made among cost, schedule, technical feasibility, and performance throughout the life of the program."[79] However, since these policies do not cover all acquisition programs, their applicability is limited.

Off-Ramp Capabilities as Needed

Leading companies will off-ramp non-critical capabilities that present a risk to delivering the product on schedule. We reviewed policies for provisions that require programs to consider a means to de-scope capabilities or requirements, or reallocate the priority of releases to maintain schedule. We found that DOD policies partially address this sub-principle. The software policy requires the program office to develop and maintain program backlogs that identify detailed user needs in prioritized lists. The backlogs allow for "dynamic reallocation of current and planned software releases," and the instruction states that "issues, errors, threats, and defects identified during development and

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[76]DOD Instruction 5000.02.

[77]DOD Instruction 5000.02.

[78]DOD Instruction 5000.87.

[79]DOD Instruction 5000.87.

operations, including software updates from third parties or suppliers, should be captured in the program's backlogs to address in future iterations and releases."[80]

The major capability policy provides a path to use a Modular Open Systems Approach (MOSA) that also requires that programs describe opportunities for off-ramping capabilities. Specifically, for major defense acquisition programs that use MOSA, the acquisition strategy must describe the evolution of capabilities that will be "added, removed, or replaced in future increments."[81] While both policies represent partial alignment with the sub-principle, the software policy is limited in its applicability to DOD programs. The major capability policy specifies that for an MDAP that uses MOSA, the acquisition strategy must describe the evolution of capabilities that will be added, removed, or replaced in future increments, but does not address decisions to remove or replace capabilities once development has begun. In addition, neither DOD Directive 5000.01 nor DOD Instruction 5000.02 addresses off-ramping to deliver a product on schedule.

DOD acquisition officials acknowledged that there is not currently a process for programs to off-ramp capabilities. However, according to these officials, the department is currently exploring opportunities through portfolio management to balance capability requirements across programs. DOD officials said this would allow some programs to stop pursuing capabilities because other programs can fill those roles. DOD currently has an outstanding priority recommendation from GAO regarding portfolio management that applies to these opportunities.
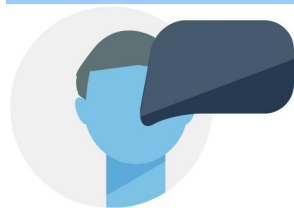
Principle 4: Collect Customer Feedback to Inform Improvements to the Minimum Marketable Product

Facilitate Ongoing Customer Engagement after Product Release

The leading companies we reviewed establish a process to facilitate ongoing engagement with customers after product release. We reviewed policies for provisions that require processes for evaluating stakeholder or end-user satisfaction with the final product. We found that DOD policies partially implement this sub-principle. The software policy requires value assessments at least annually after the software is fielded. These

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[80]DOD Instruction 5000.87.

[81]DOD Instruction 5000.85.

value assessments determine if the mission improvements or efficiencies realized from the delivered software are timely and worth the current and future investments from the end-user perspective.[82] Additionally, the product support management policy addresses ways for programs to incorporate the user community during testing. Specifically, the policy requires the product support manager for programs to "work with systems engineers and the testing and user communities to incorporate the costs and manpower planning necessary to conduct user supportability related demonstration and evaluation events into the test strategy."[83] DOD acquisition officials stated that while the policy does not include language requiring this sub-principle, the Joint Staff fulfill this role when they coordinate with the Combatant Commands to determine capability needs prior to beginning a new acquisition program.[84] For example, according to acquisition officials, the Joint Staff conducts an annual Capability Gap analysis to determine how new acquisition programs can fill those gaps, such as with the Urgent Capability pathway. These same officials also said that the Joint Staff conducts annual visits with the Commands to provide training on capabilities.

Use Customer Feedback in Subsequent Releases

In addition to establishing a process to collect customer feedback, the leading companies in our review use that feedback to identify problems with the product and new features customers want in future releases. We reviewed policies for provisions that require the inclusion of feedback from stakeholders or end users to update mission deficiencies, upgrades, or subsequent releases of the product. We found that DOD policies partially implement this sub-principle. The software policy establishes that the purpose of the planning phase is to better understand the users' needs and plan the approach to deliver software capabilities to meet those needs.[85] The policy also requires that the program office "actively engage users throughout the software life cycle to understand their mission deficiencies [and] required enhancements to existing operational capabilities," among other things.[86]

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[82]DOD Instruction 5000.87.

[83]DOD Instruction 5000.91.
[84]The Joint Staff has enterprise-level responsibilities related to the requirements process, including identifying, assessing, validating, and prioritizing capability needs.

[85]DOD Instruction 5000.87.

[86]DOD Instruction 5000.87.

Appendix IV: Department of Homeland Security Policy Analysis

Figure 13: Department of Homeland Security (DHS) Policies Reflect Some Key Business Case and Iterative Design Product Development Sub-Principles

Department of Homeland Security

Principle 1: Attain a sound business case that is informed by research along with collaboration with customers

Sub-principles

1) Invest time to research a marketable product.

2) Solicit early feedback from customers for both hardware and software development.

3) Develop cost, schedule, and performance tenets, or parameters, to define project goals before allocating initial funding.

4) Preserve institutional memory and share corporate knowledge in order to develop initial estimates, avoid earlier mistakes, and build on previous success.

5) Continuously evaluate cost, schedule, and performance parameters to ensure a high level of confidence in the project team's ability to deliver the product within cost and schedule targets prior to committing to a public release date.

6) Employ right-sized teams that have sufficient experience and autonomy to develop the product.

7) Willing to end product development if the product no longer has a sound business case.

Principle 2: Use an iterative design approach that results in minimum marketable products

Sub-principles

1) Use modern design tools during both hardware and software development that enable multiple design iterations.

2) Use elements of Agile development methodologies that promote iteration in both hardware and software product development.

3) Use iterative design and testing to identify a minimum marketable product that can be followed by successive updates for both hardware and software development.

Key principles

- Agency policies do not implement the majority of the sub-principles in the key principle
- Agency policies partially implement the majority of the sub-principles in the key principle
- Agency policies fully implement all of the sub-principles in the key principle

Sub-principles

- Agency policies do not implement the sub-principle
- Agency policies either partially implement the sub-principle or only apply to a subset of acquisition programs
- Agency policies fully implement the sub-principle for all acquisition program types

Source: GAO analysis of DHS data. | GAO-22-104513

Text of Figure 13: Department of Homeland Security (DHS) Policies Reflect Some Key Business Case and Iterative Design Product Development Sub-Principles

Principle 1: Attain a sound business case that is informed by research along with collaboration with customers. (Agency policies partially implement the majority of the sub-principles in the key principle)

1. Invest time to research a marketable product. (Agency policies fully implement the sub-principle for all acquisition program types)

2. Solicit early feedback from customers for both hardware and software development. (Agency policies fully implement the sub-principle for all acquisition program types)

3. Develop cost, schedule, and performance tenets, or parameters, to define project goals before allocating initial funding. (Agency policies fully implement the sub-principle for all acquisition program types)

4. Preserve institutional memory and share corporate knowledge in order to develop initial estimates, avoid earlier mistakes, and build on previous success. (Agency policies either partially implement the sub-principle or only apply to a subset of acquisition programs)

5. Continuously evaluate cost, schedule, and performance parameters to ensure a high level of confidence in the project team's ability to deliver the product within cost and schedule targets prior to committing to a public release date. (Agency policies fully implement the sub-principle for all acquisition program types)

6. Employ right-sized teams that have sufficient experience and autonomy to develop the product. (Agency policies fully implement the sub-principle for all acquisition program types)

7. Willing to end product development if the product no longer has a sound business case. (Agency policies do not implement the sub-principle)

Principle 2: Use an iterative design approach that results in minimum marketable products. (Agency policies partially implement the majority of the sub-principles in the key principle)

1. Use modern design tools during both hardware and software development that enable multiple design iterations. (Agency policies do not implement the sub-principle)

2. Use elements of Agile development methodologies that promote iteration in both hardware and software product development. (Agency policies fully implement the sub-principle for all acquisition program types)

3. Use iterative design and testing to identify a minimum marketable product that can be followed by successive updates for both hardware and software development. (Agency policies either partially implement the sub-principle or only apply to a subset of acquisition programs)

Source: GAO analysis of DHS data. | GAO-22-104513

Figure 14: Department of Homeland Security (DHS) Policies Reflect Some Key Schedule and Customer Feedback Product Development Sub-Principles

Department of Homeland Security

Principle 3: Prioritize schedule by off-ramping capabilities when necessary

Sub-principles

1) Use periodic reviews throughout the product development process to monitor project performance, and take steps to ensure development remains on course.

2) Maintain a realistic assessment of product development activities, with a willingness to make difficult decisions about capabilities.

3) Off-ramp capabilities that present a risk to delivering the product on schedule.

Principle 4: Collect customer feedback to inform improvements to the minimum marketable product

Sub-principles

1) Establish a process to facilitate ongoing engagement with customers after product release.

2) Use customer feedback to identify challenges to address and new features to include in subsequent releases.

Key principles

Agency policies do not implement the majority of the sub-principles in the key principle

Agency policies partially implement the majority of the sub-principles in the key principle

Agency policies fully implement all of the sub-principles in the key principle

Sub-principles

Agency policies do not implement the sub-principle

Agency policies either partially implement the sub-principle or only apply to a subset of acquisition programs

Agency policies fully implement the sub-principle for all acquisition program types

Source: GAO analysis of DHS data. | GAO-22-104513

Text of Figure 14: Department of Homeland Security (DHS) Policies Reflect Some Key Schedule and Customer Feedback Product Development Sub-Principles

Principle 3: Prioritize schedule by off-ramping capabilities when necessary. (Agency policies partially implement the majority of the sub-principles in the key principle)

1. Use periodic reviews throughout the product development process to monitor project performance, and take steps to ensure development remains on course. (Agency policies fully implement the sub-principle for all acquisition program types)

2. Maintain a realistic assessment of product development activities, with a willingness to make difficult decisions about capabilities. Agency policies fully implement the sub-principle for all acquisition program types)

3. Off-ramp capabilities that present a risk to delivering the product on schedule. . (Agency policies do not implement the sub-principle)

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Principle 4: Collect customer feedback to inform improvements to the minimum marketable product. (Agency policies fully implement all of the sub-principles in the key principle)

1. Establish a process to facilitate ongoing engagement with customers after product release. (Agency policies fully implement the sub-principle for all acquisition program types)

2. Use customer feedback to identify challenges to address and new features to include in subsequent releases. (Agency policies fully implement the sub-principle for all acquisition program types)

Source: GAO analysis of DHS data. | GAO-22-104513

Principle 1: Attain a Sound Business Case that Is Informed by Research along with Collaboration with Customers

Invest Time to Research a Marketable Product

Leading companies utilize various methods to determine whether there is a market for a proposed product. We reviewed policies for provisions that that require programs and projects to be credible and achievable, and to be based on validated needs.[87] We found that Department of Homeland Security (DHS) policies fully implement this sub-principle by requiring that acquisition programs be based on demonstrated needs and present realistic, achievable solutions. For example, according to the DHS Acquisition Management Instruction, before program approval, DHS officials are required to develop a Mission Need Statement that has been validated by the Joint Requirements Council to determine whether or not an acquisition program is the appropriate solution.[88] In addition, as programs progress through the acquisition life-cycle framework, DHS's Systems Engineering Life Cycle Instruction requires that technical reviews determine whether program plans establish realistic and effective solutions.[89] It also requires that Solution Analysis Reviews are conducted at the end of the solution analysis phase to determine whether the operational requirements, concept of operations, and integrated logistics support strategy for the solution have been adequately defined and are supported by objective analysis.

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[87]We reviewed DHS's department-wide acquisition management principles found in DHS Acquisition Management Directive 102-01, DHS Test Evaluation Directive 026-06, and Joint Requirements Integration and Management System Directive 107-01. We also reviewed DHS Instructions that outline acquisition management expectations in greater detail. These included DHS Instruction 102-01-001, *Acquisition Management Instruction*; DHS Instruction 102-01-103, *Systems Engineering Life Cycle Instruction*; DHS Instruction 102-01-004, *Agile Methodology for Software Development and Delivery for Information Technology*; DHS Instruction Manual 102-01-004-01, *Agile Development and Delivery for Information Technology;* DHS Instruction 102-01-006, *Acquisition Program Management Staffing Instruction*; DHS Instruction 026-06-001, *Test and Evaluation Instruction;* and DHS Instruction Manual 107-01-001-01, *Manual for the Operation of the Joint Requirements Integration and Management System.*

[88]DHS Instruction 102-01-001.

[89]DHS Instruction 102-01-103.

<u>Solicit Early Feedback from Customers for Hardware and Software Development</u>

Obtaining feedback from new and existing customers for a potential product is an important aspect of attaining a sound business case for leading companies. We reviewed policies for provisions that require stakeholder or end-user involvement in early program planning stages. We found that DHS policies fully implement this sub-principle by requiring that acquisition programs include end users in the establishment of operational performance requirements. For example, the DHS Acquisition Management Instruction states that the accurate definition of requirements by users is imperative if the mission is to meet performance needs within cost and schedule constraints, and that the user establishes absolute performance minimums below which the mission cannot be successfully performed.[90] In addition, it requires programs to engage end users in capturing operational gaps and defining the need for the program as it aligns to strategic DHS direction.

<u>Develop Cost, Schedule, and Performance Parameters</u>

Leading companies define the goals of the product under development using cost, schedule, and performance tenets, or parameters, before allocating initial funding to the product development project. We reviewed policies for provisions that require development of cost, schedule, and performance requirements or parameters in early program planning stages. We found that DHS policies fully implement this sub-principle by requiring program plans to include parameters for cost, schedule, and performance. Specifically, the DHS Acquisition Management Instruction requires that:

- Cost parameters in the acquisition program baseline must include objective and threshold values for research and development, procurements, construction, improvement costs, and average annual operations and support costs calculated from the full operational capacity date to the defined end of the program or project.

- Schedule parameters must include the date that the program or projects will reach acquisition decision events, initial operational capacity, full operational capacity, and additional key events as necessary.

- Performance parameters in the acquisition program baseline are the key performance parameters established by the approved operational requirements document.[91]

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[90]DHS Instruction 102-01-001.

[91]DHS Instruction 102-01-001.

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Preserve Institutional Memory and Share Corporate Knowledge

Leading companies have established processes—formal and informal—for preserving institutional memory and sharing corporate knowledge in order to develop initial estimates, avoid earlier mistakes, and build on previous success. We reviewed policies for provisions that require documenting and sharing knowledge or lessons learned to develop initial goals or plans. We found that DHS policies partially implement this sub-principle. The DHS Systems Engineering Life Cycle Instruction requires programs to capture lessons learned at the end of the development process.[92] The policy states that post implementation reviews are conducted, in part, to determine whether the implemented solution meets mission outcomes and provides anticipated benefits; identify deficiencies; recommend how mission outcomes may be better achieved; and capture lessons learned.

Moreover, in response to our prior recommendation, DHS updated its post implementation review guidance to establish formal reporting requirements and standardize analysis elements of the reviews.[93] However, DHS policies do not outline a consistent method to share lessons learned across the agency. Policies also do not require programs to incorporate the lessons learned by earlier program teams into their initial plans. DHS officials acknowledged that there was no requirement for program managers to research lessons learned before starting a program, but told us that the agency has many opportunities for this to be done in practice. For example, the officials reported regularly occurring forums sponsored by the Chief Acquisition Officer, monthly meetings with acquisition officers from across the agency, and an annual symposium to share presentations on lessons learned. They also told us that the Coast Guard maintained a lessons learned database but that no such resource was available across all components.

Evaluate Cost, Schedule, and Performance Parameters Continuously

Leading companies ensure a high level of confidence in the project team's ability to deliver a product within cost and schedule targets by continuously evaluating cost, schedule, and performance parameters before committing to a public release date. We reviewed policies for provisions that require a high confidence level in cost and schedule estimates, and for programs to reevaluate, update, or mature these estimates if needed prior to program commitment. We found that DHS policies fully implement this sub-principle. The DHS Acquisition Management Instruction requires programs to establish preliminary cost, schedule, and performance parameters, and to reevaluate their initial estimates before approval of official program baselines. It also requires programs to set

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[92]DHS Instruction 102-01-103.

[93]GAO, *Homeland Security Acquisitions: Leveraging Programs' Results Could Further DHS's Progress to Improve Portfolio Management*, GAO-18-339SP (Washington, D.C.: May 17, 2018).

objective and threshold parameters based on an objective life-cycle cost estimate that has been approved by the DHS Chief Financial Officer. While objective parameters need only be set at the 50 percent confidence level within their estimate ranges, threshold parameters are set up to 15 percent higher than objective parameters in order to provide programs with a financial buffer.[94] Therefore, program teams can have more confidence in their ability to deliver the final product within cost targets than not.

Employ Right-Sized Teams

Leading companies focus on ensuring they have the right project team with sufficient experience and autonomy for their product development project. We reviewed policies for provisions that require program plans to include staffing plans or an outline of key or necessary personnel that address authority and responsibility, and descriptions of teams being experienced, empowered, or having autonomy in assigned duties. We found that DHS policies fully implement this sub-principle. DHS policies require detailed staffing plans, and grant certain authorities and responsibilities to program and project managers and other critical acquisition program management positions.

For example, the DHS Acquisition Management Instruction states that program managers are responsible for managing their assigned acquisition programs and for ensuring that they effectively deliver required capability performance to their customers while remaining within the allocated resources provided by their organizations to adhere to cost, schedule, and performance baselines.[95] The DHS Acquisition Program Management Staffing policy states that "DHS major acquisition programs require a sufficient number of trained and qualified acquisition program management staff with the proper skills and experience in the appropriate acquisition disciplines to manage and execute programs in order to obtain successful acquisition outcomes."[96] Moreover, DHS guidance for information technology development recommends the use of small teams that are accountable for incremental product delivery.[97]

End Product Development if Needed

Leading companies will end product development if the product no longer has a sound business case. We reviewed policies for provisions that require programs to consider resource allocation or termination if the program no longer provides value, fails to stay within parameters, or in the case of a cost or schedule breach. We found that DHS

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[94]DHS Instruction 102-01-001.

[95]DHS Instruction 102-01-001.

[96]DHS Instruction 102-01-006.

[97]DHS Manual 102-01-004-01.

policies do not implement this sub-principle. DHS's Acquisition Management Instruction states that a program may be cancelled or terminated "for any number of reasons."[98] However, those reasons are not defined, and no guidance is given to consider a program for termination in case of a breach of cost or schedule parameters. Instead, if a program breaches an approved threshold or the program manager forecasts that the program would breach in the future, the program enters a remediation planning process. DHS officials told us that program termination is a significant decision requiring approval from the Secretary of Homeland Security. Therefore, the agency prefers to pursue remediation options before considering a program for termination in the case of a breach.

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[98]DHS Instruction 102-01-001.

Principle 2: Use an Iterative Design Approach that Results in Minimum Marketable Products

Use Modern Design Tools

Leading companies link their use of modern design tools during both hardware and software development to the ability to successfully iterate on design. We reviewed policies for provisions that require government and contractor software and hardware teams to use modern design tools or digital engineering to iterate on design. We found that DHS policies do not implement this sub-principle. None of the acquisition policies we reviewed reference the use of modern design tools or practices. The use of tools such as digital engineering and additive manufacturing help leading companies to move quickly and efficiently through the design process, and reduce the need for costly changes later in the product life cycle. DHS officials told us that such details are often included in individual contracts. However, they said it could be difficult to include such details in a department-wide agency policy because they are too specific to be appropriate for all program types. Nevertheless, language emphasizing the importance of modern design tools in department-wide policy would provide program managers greater direction on agency expectations for the structure and execution of their programs.

Use Elements of Agile Development Methodologies

Leading companies use Agile development methodologies to promote iteration in both hardware and software development. We reviewed policies for provisions that require modern iterative development or adaptive development methodologies (e.g., Agile) that promote iteration in development for both hardware and software. We found that DHS policies fully implement this sub-principle by including provisions for elements of iterative development for both hardware and software programs. For example, DHS established Agile development as the required approach for software development and delivery for information technology programs and projects. The DHS Instruction for Agile Methodology for Software Development and Delivery for Information Technology states that Agile development "promotes continuous adaptive planning, development, testing, delivery and integration, and encourages rapid and flexible response to change between self-organizing and cross functional teams."[99] Although Agile development is not

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[99]DHS Instruction 102-01-004.

required for hardware, the Systems Engineering Life Cycle Instruction depicts functional design, physical design, and development occurring in an iterative loop, with integration and test activities occurring throughout.[100] Moreover, programs can include incremental delivery or low-rate initial production to support operational testing and allow continuous production.[101]

<u>Use Iterative Design and Testing to Identify a Minimum Marketable Product</u>

Leading companies use iterative design and testing to identify a minimum marketable product that can be followed by successive updates to that product. We reviewed policies for provisions requiring development of a minimum viable product or initial capability to be improved by subsequent or evolving releases. We found that DHS policies partially implement this sub-principle. Though the DHS Systems Engineering Life Cycle Instruction requires all programs to use an iterative testing and design approach, only incremental software development programs are required to use this iteration to identify a minimum viable product.[102] DHS officials acknowledged that their acquisition policies did not require programs to identify a minimum viable product but said that many programs did release new capabilities incrementally in practice. For example, they told us that the first National Security Cutter was deployed without some capabilities that were too resource-intensive to include in the first release. As the agency was able to develop those additional capabilities, they were included in iterative releases of the National Security Cutter.

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[100]DHS Instruction 102-01-103.

[101]DHS Instruction 102-01-001.

[102]DHS Instruction 102-01-103.

Principle 3: Prioritize Schedule by Off-Ramping Capabilities When Necessary

Conduct Oversight through Periodic Reviews

Leading companies use periodic reviews throughout the product development process to monitor project performance and to take steps to ensure development remains on course. We reviewed policies for provisions that require milestones or decision events that include reviews of product development progress or deviation to determine whether the program can proceed with planned development activities. We found that DHS policies fully implement this sub-principle by requiring periodic decision events throughout product development. The DHS Acquisition Management Instruction states: "The DHS acquisition life cycle process is structured to operate within a series of acquisition phases each leading to an acquisition decision event and acquisition decision authority decision."[103] Programs must meet the requirements for each acquisition decision event to progress to the next phase or decision event in the acquisition life cycle.

Maintain a Realistic Assessment of Product Development Activities

Leading companies maintain a realistic assessment of product activities, with a willingness to make difficult decisions about capabilities. We reviewed policies for provisions that require proven or objective processes for reviews to evaluate product development activities and permit higher-level officials to redirect programs or make trade-offs in the event of a problem. We found that DHS policies fully implement this sub-principle by requiring the use of proven systems engineering principles and processes to oversee capability development and empowering program officials to make trade-offs as necessary.

The DHS Acquisition Management Instruction requires that systems engineering life cycle reviews be used to inform component and departmental oversight structure on the progress toward successful capability development.[104] It also requires programs to successfully complete testing and evaluation; an assessment of the effectiveness, suitability, and resilience; and the preparation of all required documentation before

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[103]DHS Instruction 102-01-001.

[104]DHS Instruction 102-01-001.

proceeding to the production and deployment phase of the acquisition life cycle. In cases where programs are not fully funded, the component must identify the trade-offs necessary to fund the program with existing resources, or adjust scope and/or schedule to make the acquisition affordable. For information technology programs, the product owner is empowered to make difficult product decisions, including prioritization of features in development, and is responsible for ensuring that requirements prioritization and refinement decisions maximize mission value.[105]

Off-ramp Capabilities as Needed

Leading companies will off-ramp non-critical capabilities that present a risk to delivering the product on schedule. We reviewed policies for provisions that require programs to consider a means to de-scope capabilities or requirements, or reallocate the priority of releases to maintain schedule. We found that DHS policies do not implement this sub-principle. The DHS Acquisition Management Instruction states: "If the program is not fully funded….the Component must identify the trade-offs necessary to fund the program within existing resources, or the Component must adjust scope and/or schedule to make the acquisition affordable." Although this policy provides programs the option to de-scope in order to stay within budget, there is no requirement that they do so in order to preserve schedule.

We found that leading companies prioritize schedule in cases where individual product features prove to be more difficult or resource-intensive than initially estimated. By off-ramping those features for future iterations of the product, leading companies are able to deliver other capabilities to the end user more quickly. DHS officials told us that, in practice, program managers are able to make trade-offs between capabilities that are not tied to key performance parameters. However, this authority is not outlined in policy.

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[105]DHS Manual 102-01-004-01.
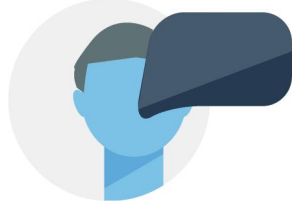
Principle 4: Collect Customer Feedback to Inform Improvements to the Minimum Marketable Product

Facilitate Ongoing Customer Engagement after Product Release

Leading companies establish a process to facilitate ongoing engagement with customers after product release. We reviewed policies for provisions that require processes for evaluating stakeholder or end-user satisfaction with the final product. We found that DHS policies fully implement this sub-principle by requiring the collection of feedback to ensure that the final products meet end-user needs. The DHS Systems Engineering Life Cycle Instruction requires that post-implementation reviews be conducted to determine whether the implemented solution meets mission outcomes and provides anticipated benefits, and evaluate stakeholder and customer or user satisfaction with the end product.[106] Moreover, it requires components to establish a Lead Business Authority for each program. This individual is responsible for "providing continuous feedback to the program on behalf of the user community" to ensure that the program accurately reflects the needs of the users throughout development.[107]

Use Customer Feedback in Subsequent Releases

Leading companies use customer feedback to identify challenges to address and new features to include in subsequent product releases. We reviewed policies for provisions that require the inclusion of feedback from stakeholders or end users to update mission deficiencies, upgrades, or subsequent releases of the product. We found that DHS policies fully implement this sub-principle. The DHS Acquisition Management Instruction states that user-identified needs, results from post-implementation reviews, and annual operational analyses are used to identify capability needs for new programs.[108] DHS guidance for information technology development explicitly requires user feedback to be incorporated into subsequent product iterations.[109]

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[106]DHS Instruction 102-01-103.

[107]DHS Instruction 102-01-103.

[108]DHS Instruction 102-01-001.

[109]DHS Manual 102-01-004-01.

For example, guidance instructs product managers to develop a project roadmap for an initial minimum viable product that will be built upon in subsequent releases. Project managers must work with end users or stakeholders to continually reassess and update the project roadmap as the project progresses and the release strategy evolves. DHS officials told us that the Lead Business Authority acting on behalf of the user community is, in practice, also responsible for using customer feedback to determine what should be included in future program developments.

Appendix V: National Aeronautics and Space Administration Policy Analysis

Figure 15: NASA Policies Reflect Some Key Business Case and Iterative Design Product Development Sub-Principles

National Aeronautics and Space Administration (NASA)

Principle 1: Attain a sound business case that is informed by research along with collaboration with customers

Sub-principles

1) Invest time to research a marketable product.

2) Solicit early feedback from customers for both hardware and software development.

3) Develop cost, schedule, and performance tenets, or parameters, to define project goals before allocating initial funding.

4) Preserve institutional memory and share corporate knowledge in order to develop initial estimates, avoid earlier mistakes, and build on previous success.

5) Continuously evaluate cost, schedule, and performance parameters to ensure a high level of confidence in the project team's ability to deliver the product within cost and schedule targets prior to committing to a public release date.

6) Employ right-sized teams that have sufficient experience and autonomy to develop the product.

7) Willing to end product development if the product no longer has a sound business case.

Principle 2: Use an iterative design approach that results in minimum marketable products

Sub-principles

1) Use modern design tools during both hardware and software development that enable multiple design iterations.

2) Use elements of Agile development methodologies that promote iteration in both hardware and software product development.

3) Use iterative design and testing to identify a minimum marketable product that can be followed by successive updates for both hardware and software development.

Key principles

☐ Agency policies do not implement the majority of the sub-principles in the key principle

▮ Agency policies partially implement the majority of the sub-principles in the key principle

▮ Agency policies fully implement all of the sub-principles in the key principle

Sub-principles

☐ Agency policies do not implement the sub-principle

▮ Agency policies either partially implement the sub-principle or only apply to a subset of acquisition programs

▮ Agency policies fully implement the sub-principle for all acquisition program types

Source: GAO analysis of NASA data. | GAO-22-104513

Text of Figure 15: NASA Policies Reflect Some Key Business Case and Iterative Design Product Development Sub-Principles

Principle 1: Attain a sound business case that is informed by research along with collaboration with customers (Agency policies fully implement all of the sub-principles in the key principle)
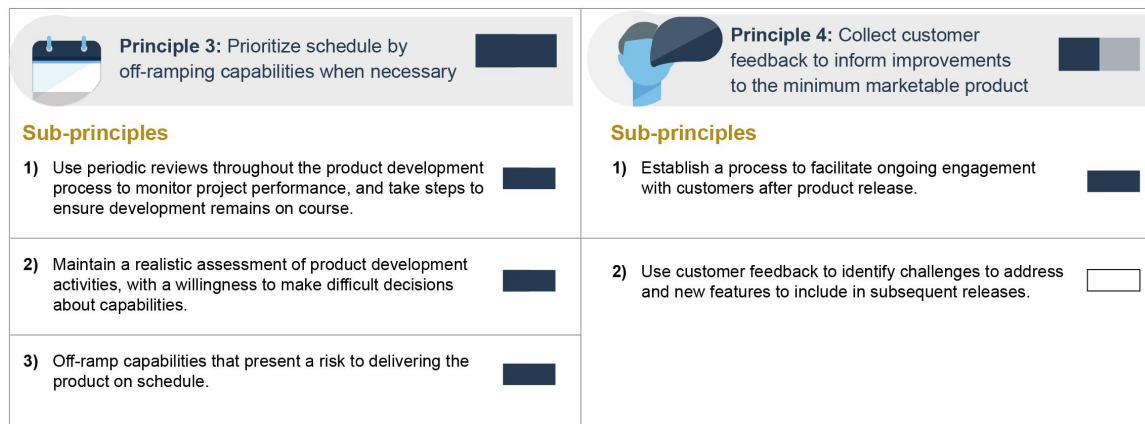
1. Invest time to research a marketable product. (Agency policies fully implement the sub-principle for all acquisition program types)

2. Solicit early feedback from customers for both hardware and software development. (Agency policies fully implement the sub-principle for all acquisition program types)

3. Develop cost, schedule, and performance tenets, or parameters, to define project goals before allocating initial funding. (Agency policies fully implement the sub-principle for all acquisition program types)

4. Preserve institutional memory and share corporate knowledge in order to develop initial estimates, avoid earlier mistakes, and build on previous success. (Agency policies fully implement the sub-principle for all acquisition program types)

5. Continuously evaluate cost, schedule, and performance parameters to ensure a high level of confidence in the project team's ability to deliver the product within cost and schedule targets prior to committing to a public release date. (Agency policies fully implement the sub-principle for all acquisition program types)

6. Employ right-sized teams that have sufficient experience and autonomy to develop the product. (Agency policies fully implement the sub-principle for all acquisition program types)

7. Willing to end product development if the product no longer has a sound business case. (Agency policies fully implement the sub-principle for all acquisition program types)

Principle 2: Use an iterative design approach that results in minimum marketable products (Agency policies partially implement the majority of the sub-principles in the key principle)

1. Use modern design tools during both hardware and software development that enable multiple design iterations. (Agency policies either partially implement the sub-principle or only apply to a subset of acquisition programs)

2. Use elements of Agile development methodologies that promote iteration in both hardware and software product development. (Agency policies fully implement the sub-principle for all acquisition program types)

3. Use iterative design and testing to identify a minimum marketable product that can be followed by successive updates for both hardware and software development. (Agency policies do not implement the sub-principle)

Figure 16: NASA Policies Reflect Some Key Schedule and Customer Feedback Product Development Sub-Principles

National Aeronautics and Space Administration (NASA)

Source: GAO analysis of NASA data. | GAO-22-104513

Text of Figure 16: NASA Policies Reflect Some Key Schedule and Customer Feedback Product Development Sub-Principles

Principle 3: Prioritize schedule by off-ramping capabilities when necessary. (Agency policies fully implement all of the sub-principles in the key principle)

1. Use periodic reviews throughout the product development process to monitor project performance, and take steps to ensure development remains on course. (Agency policies fully implement the sub-principle for all acquisition program types)

2. Maintain a realistic assessment of product development activities, with a willingness to make difficult decisions about capabilities. (Agency policies fully implement the sub-principle for all acquisition program types)

3. Off-ramp capabilities that present a risk to delivering the product on schedule. (Agency policies fully implement the sub-principle for all acquisition program types)

Principle 4: Collect customer feedback to inform improvements to the minimum marketable product. (Agency policies partially implement the majority of the sub-principles in the key principle)

1. Establish a process to facilitate ongoing engagement with customers after product release. (Agency policies fully implement the sub-principle for all acquisition program types)

2. Use customer feedback to identify challenges to address and new features to include in subsequent releases. (Agency policies do not implement the sub-principle)

Principle 1: Attain a Sound Business Case that Is Informed by Research along with Collaboration with Customers

<u>Invest Time to Research a Marketable Product</u>

Leading companies utilize various methods to determine whether there is a market for a proposed product. We reviewed policies for provisions that require programs and projects to be credible and achievable, and to be based on previously-identified needs.[110] We found that National Aeronautics and Space Administration (NASA) policies fully implement this sub-principle by requiring that programs and projects address previously identified needs and develop credible and affordable baseline estimates. The Policy for NASA Acquisition requires that all new acquisitions are reviewed by senior agency management to ensure they fulfill an identified need that is aligned with the NASA Strategic Plan and are compatible with expected resources and capabilities.[111] Moreover, the NASA Space Flight Program and Project Management Handbook states that programs are to develop credible cost and schedule estimates and to demonstrate that proposed projects are feasible within available resources.[112]

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[110]We reviewed NASA's department-wide acquisition management principles found in NASA Policy Directive 1000.0C, *NASA Governance and Strategic Management Handbook* (Jan. 29, 2020); NASA Policy Directive 1000.3E with Change 85, *NASA Organization* (April 15, 2015); NASA Policy Directive 1000.5C, *Policy for NASA Acquisition* (July 13, 2020); NASA Policy Directive 7120.4E, *NASA Engineering and Program/Project Management Policy* (June 26, 2017); and NASA Policy Directive 7120.6A, *Knowledge Policy for Programs and Projects* (Dec. 16, 2019). We also reviewed NASA Procedural Requirements and Handbooks that outline acquisition management expectations in greater detail. These included NASA Procedural Requirement 7120.5F, *NASA Space Flight Program and Project Management Requirements* (Aug. 3, 2021); NASA Procedural Requirement 7123.1C, *NASA Systems Engineering Processes and Requirements with Change 1* (Feb. 14, 2020); NASA Procedural Requirement 7120.7A, *Information Technology Program and Project Management Requirements* (Aug. 17, 2020); NASA Procedural Requirement 7150.2C, *Software Engineering Requirements* (Aug. 2, 2019); NASA Procedural Requirement 8735.2C, *Hardware Quality Assurance Program Requirements for Programs and* Projects *(Updated with Change 1),* (March 12, 2021); and *NASA Space Flight Program and Project Management Handbook*, NASA/SP-2014-3705 (September 2014).

[111]NASA Policy Directive 1000.5C.

[112]NASA/SP-2014-3705.

Solicit Early Feedback from Customers for Hardware and Software Development

Obtaining feedback from new and existing customers for a potential product is an important aspect to attaining a sound business case for leading companies. We reviewed policies for provisions that require stakeholder or end-user involvement in early program planning stages. We found that NASA policies fully implement this sub-principle by requiring that programs and projects define stakeholder expectations before establishing initial technical requirements. NASA's Systems Engineering Processes and Requirements policy requires a Stakeholder Expectations Definition process to elicit and define use cases, scenarios, concept of operations, and stakeholder expectations of the applicable life-cycle phase.[113] It also requires program and project officials to identify and implement technical requirements from the set of agreed-upon stakeholder expectations.

Develop Cost, Schedule, and Performance Parameters

Leading companies define the goals of the product under development using cost, schedule, and performance tenets, or parameters, before allocating initial funding to the product development project. We reviewed policies for provisions that require development of cost, schedule, and performance requirements or parameters in early program planning stages. We found that NASA policies fully implement this sub-principle by providing guidance for programs to set initial cost, schedule, and capability requirements as part of the agency baseline commitment at the start of the life cycle. According to the NASA Space Flight Program and Project Management Handbook, the agency baseline commitment is the baseline against which the agency's performance is measured throughout program development.[114]

Preserve Institutional Memory and Share Corporate Knowledge

Leading companies have established processes—formal and informal—for preserving institutional memory and sharing corporate knowledge in order to develop initial estimates, avoid earlier mistakes, and build on previous success. We reviewed policies for provisions that require documenting and sharing knowledge or lessons learned to develop initial goals or plans. We found that NASA policies fully implement this sub-principle by providing guidance for programs to capture lessons learned in a knowledge management plan, and consult prior programs' lessons learned while developing initial plans. NASA also maintains multiple resources for recording and sharing knowledge between programs, described in its Knowledge Policy for Programs and Projects.[115] These include a Lessons Learned Information System, and the Academy of Program/Project and Engineering Leadership Knowledge Services website, where

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[113]NASA Procedural Requirement 7123.1C.

[114]NASA/SP-2014-3705.

[115]NASA Policy Directive 7120.6A.

NASA's technical workforce can find knowledge needed to support project learning and mission success.

Evaluate Cost, Schedule, and Performance Parameters Continuously

Leading companies ensure a high level of confidence in the project team's ability to deliver a product within cost and schedule targets by continuously evaluating cost, schedule, and performance parameters before committing to a public release date. We reviewed policies for provisions that require a high confidence level in cost and schedule estimates, and for programs to reevaluate, update, or mature these estimates if needed prior to program commitment. We found that NASA policies fully implement this sub-principle by requiring programs and projects to reevaluate their initial parameters throughout the Formulation Phase of acquisition, and maintain a high level of confidence in their ability to meet cost and schedule targets.

The NASA Space Flight Program and Project Management Handbook generally establishes that: "At the beginning of the Formulation Phase, there is a relative lack of maturity and broad uncertainties regarding the program or project's scope, technical approach, safety objectives, acquisition strategy, implementation schedule, and associated costs. During Formulation, these program or project parameters are developed and matured."[116] The NASA Space Flight Program and Project Management Requirements policy generally establishes that by the end of Formulation, major projects establish budgets based on a 70 percent joint cost and schedule confidence level, thus ensuring that projects are likely to have the resources needed to complete their acquisition plans successfully.[117]

Employ Right-Sized Teams

Leading companies focus on ensuring they have the right project team with sufficient experience and autonomy for their product development project. We reviewed policies for provisions that require program plans to include staffing plans or an outline of key or necessary personnel that address authority and responsibility, and descriptions of teams being experienced, empowered, or having autonomy in assigned duties. We found that NASA policies fully implement this sub-principle by requiring programs to develop a management framework identifying roles and responsibilities for each involved organization, and a project plan outlining the roles and responsibilities of key team members.[118] Moreover, NASA's Governance and Strategic Management Handbook, an official NASA Policy Directive, highlights the importance of team members with unique

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[116]NASA/SP-2014-3705.

[117]NASA Procedural Requirement 7120.5F.

[118]NASA Procedural Requirement 7120.5F; and NASA/SP-2014-3705.

experience and expertise. It also asserts that NASA's most powerful asset for achieving mission success is a multidisciplinary team of diverse, competent people across all NASA centers.[119]

End Product Development if Needed

Leading companies will end product development if the product no longer has a sound business case. We reviewed policies for provisions that require programs to consider resource allocation or termination if the program no longer provides value, fails to stay within parameters, or in the case of a cost or schedule breach. We found that NASA policies fully implement this sub-principle by requiring projects to be considered for a termination review if they fail to stay within the cost, schedule, and performance parameters specified in controlling documents. The NASA Space Flight Program and Project Management Requirements state that termination review is "initiated by the Decision Authority for the purpose of securing a recommendation as to whether to continue or terminate a program or project."[120]

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[119]NASA Policy Directive 1000.0C.

[120]NASA Procedural Requirement 7120.5F.

Principle 2: Use an Iterative Design Approach That Results in Minimum Marketable Products

Use Modern Design Tools

Leading companies link their use of modern design tools during both hardware and software development to the ability to successfully iterate on design. We reviewed policies for provisions that require government and contractor software and hardware teams to use modern design tools or digital engineering to iterate on design. We found that NASA policies partially implement this sub-principle. Policies encourage the use of modern design tools for software development. For example, the NASA Software Engineering Requirements policy states that rigorous specification languages, graphical representations, and related tools have been developed to support the evaluation of critical properties at the design level.[121] Leadership encourages project teams to take advantage of these improved design techniques to prevent and eliminate errors as early in the life cycle as possible. However, the policy does not reference modern design tools for hardware. The use of tools such as digital engineering and additive manufacturing help leading companies to move quickly and efficiently through the design process, and reduce the need for costly changes later in the product life cycle. NASA officials told us that requirements for contractors to use specific design tools are made on a case-by-case basis but were not suitable for a department-wide acquisition policy because they expect contractors to use cutting edge tools, which evolve over time. Instead, officials expect contractors to already be using cutting edge technology because it is inherent to the development of new space technology projects.

Use Elements of Agile Development Methodologies

Leading companies use Agile development methodologies to promote iteration in both hardware and software development. We reviewed policies for provisions that require modern iterative development or adaptive development methodologies (e.g., Agile) that promote iteration in development for both hardware and software. We found that NASA policies fully implement this sub-principle. The NASA Software Engineering Requirements policy permits a range of development models, including Agile methods,

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[121]NASA Procedural Requirement 7150.2C.

spiral model, the iterative model, waterfall, and others.[122] Moreover, the NASA Systems Engineering Processes and Requirements policy requires an iterative development process for both hardware and software systems. It states that systems engineering requires the application of a systematic approach that is recursive, iterative, and repeatable throughout the life cycle of a project or program.[123] NASA officials further clarified that the use of iteration in this policy means that projects iterate on design in early life-cycle phases, and use test units to determine if design adjustments are needed over the course of development.

Use Iterative Design and Testing to Identify a Minimum Marketable Product

Leading companies use iterative design and testing to identify a minimum marketable product that can be followed by successive updates to that product. We reviewed policies for provisions requiring development of a minimum viable product or initial capability to be improved by subsequent or evolving releases. We found that NASA policies did not implement this sub-principle. Policies do not require programs or projects to identify minimum viable products for either hardware or software development. NASA's Information Technology Program and Project Management Requirements state that information technology programs may provide a proof of concept or prototype to be incorporated into later developments.[124] However, such technology demonstrations are not equivalent to completed and deployed minimum viable products, which could be updated in subsequent releases. By focusing on the features that are most critical to customer needs, leading companies are able to produce new capabilities more quickly than they would be able to do if programs were bogged down with less critical requirements.

NASA's major projects aim to explore Earth and the solar system, extend human presence beyond low Earth orbit to the lunar surface, and understand climate change, among other things. NASA officials told us that an important difference between leading companies' product development and NASA's project life cycle is that NASA cannot prototype in an operational environment. Due to the unique nature of NASA's mission, officials told us that programs cannot retrieve most products after launch for adjustments and upgrades, which limits their ability to plan for minimum viability. Officials also told us that they considered a minimum viable product to be one that met only a project's Level 1 requirements—those priority requirements that are absolutely necessary for mission viability. However, delivering a project that meets minimum requirements but does not leave open the possibility of successive updates is inconsistent with the principle used by leading companies.

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[122]NASA Procedural Requirement 7150.2C.

[123]NASA Procedural Requirement 7123.1C.

[124]NASA Procedural Requirement 7120.7A.

Principle 3: Prioritize Schedule by Off-Ramping Capabilities When Necessary

<u>Conduct Oversight through Periodic Reviews</u>

Leading companies use periodic reviews throughout the product development process to monitor project performance and to take steps to ensure that development remains on course. We reviewed policies for provisions that require milestones or decision events that include reviews of product development progress or deviation to determine whether the program can proceed with planned development activities. We found that NASA policies fully implement this sub-principle by requiring reviews that provide a periodic assessment of a program or project's technical and programmatic status and health at key points in the life cycle. The NASA Engineering and Program/Project Management Policy states that programs and projects are managed based on a phased life cycle with key decision points where a program or project's status and readiness to proceed to the next phase are determined.[125] This determination is supported by reviews throughout the life cycle.

<u>Maintain a Realistic Assessment of Product Development Activities</u>

Leading companies maintain a realistic assessment of product activities, with a willingness to make difficult decisions about capabilities. We reviewed policies for provisions that require proven or objective processes for reviews to evaluate product development activities and that permit higher-level officials to redirect programs or make trade-offs in the event of a problem. We found that NASA policies fully implement this sub-principle by requiring life-cycle reviews to be credible and objective, and by empowering Decision Authorities to use information from these reviews to redirect or disapprove programs for continuation. For example, the NASA Space Flight Program and Project Management Handbook states that at key decision points, the Decision Authority reviews all the materials and briefings at hand to make a decision about the program's maturity and readiness to progress through the life cycle.[126] In cases where programs are disapproved for continuation to the next phase, follow-up actions may

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[125]NASA Policy Directive 7120.4E.

[126]NASA/SP-2014-3705.

include a request for more information or a follow-up review; a request for a termination review; direction to continue in the current phase; or redirection of the program.

Off-ramp Capabilities as Needed

Leading companies will off-ramp non-critical capabilities that present a risk to delivering the product on schedule. We reviewed policies for provisions that require programs to consider a means to de-scope capabilities or requirements, or reallocate the priority of releases to maintain schedule. We found that NASA policies fully implement this sub-principle by requiring projects to develop de-scope plans that can be used to maintain cost and schedule goals. The NASA Space Flight Program and Project Management Requirements state that a project's Technical, Schedule, and Cost Control Plan must describe the project's de-scope plans, including key decision dates and savings in cost and schedule, and show how the de-scopes are related to the project's threshold performance requirements.[127]

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[127]NASA Procedural Requirement 7120.5F.

Principle 4: Collect Customer Feedback to Inform Improvements to the Minimum Marketable Product

Facilitate Ongoing Customer Engagement after Product Release

Leading companies establish a process to facilitate ongoing engagement with customers after product release. We reviewed policies for provisions that require processes for evaluating stakeholder or end-user satisfaction with the final product. We found that NASA policies fully implement this sub-principle. The NASA Systems Engineering Processes and Requirements policy requires programs to validate final products against original user requirements or stakeholder expectations.[128] Further, the NASA Procedural Requirement on Hardware Quality Assurance Program Requirements for Programs and Projects generally requires each NASA Center Director to maintain a quality management system that is compliant with certain international standards, including one that emphasizes obtaining customer feedback relating to products and services and monitoring customers' perceptions of the degree to which their needs and expectations have been fulfilled.[129]

NASA officials told us that stakeholder engagement is embedded in the project management process and that agency boards and councils ensure that stakeholder perspectives are considered throughout project development. However, officials also said that NASA's users are different from leading companies because they consider the agency's final product to be the science produced by their programs and projects and their end users to be the scientists who receive the technical papers that are published as a result of that science. Officials from multiple mission directorates told us that they collect customer feedback through various venues in practice. For example, the National Academy of Science's Decadal Studies and Decadal midterm reports provide the Science Mission Directorate with feedback regarding the direction and relevance of NASA science missions. However, these practices are not reflected in the agency's department-wide acquisition policies.

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[128]NASA Procedural Requirement 7123.1C.

[129]NASA Procedural Requirement 8735C; and SAE International, Aerospace Standard AS9100, *Quality Management Systems – Requirements for Aviation, Space, and Defense Organizations*, Rev. D (September 2016).

Use Customer Feedback in Subsequent Releases

Leading companies use customer feedback to identify challenges to address and new features to include in subsequent product releases. We reviewed policies for provisions that require the inclusion of feedback from stakeholders or end users to update mission deficiencies, upgrades, or subsequent releases of the product. We found that NASA policies do not implement this sub-principle. The NASA Space Flight Program and Project Management Requirements policy includes a process for program upgrades, evolution, and re-flights. For example, when programs evolve or require upgrades, the life-cycle process will be restarted when warranted.[130] However, NASA policies do not include provisions for iterative product releases and do not indicate that end-user feedback is included in iterative releases or the decision to begin a program evolution or upgrade. NASA officials told us that the majority of NASA's major projects are unique systems that have only one opportunity to succeed, rather than iterations of prior work. However, some projects, such as Landsat 9, do build on prior iterations of the same capability.[131] NASA officials also told us that, for crewed space missions, they receive continuous feedback from the astronauts using the spacecraft, which informs upgrades required between flights. However, this practice is not reflected in policy.

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[130]NASA Procedural Requirement 7120.5F.

[131]GAO, *NASA: Assessments of Major Projects*, GAO-21-306 (Washington, D.C.: May 20, 2021).

Appendix VI – Leading Company Common Product Development Activities

Figure 17: Leading Company Common Product Development Activities

A Concept

Product development begins with companies exploring product concepts and selecting a product to invest in and pursue. Leading companies undertake this exploration as part of an annual planning process with senior leadership. The process concludes with formation of a project team assigned to develop the selected concept.

B Scoping

After completing concept development and assembling the project team, senior leadership provides limited initial funding to the project team to begin their work. Senior leadership also sets guidelines for obtaining future funding based on product development progress. The project team then begins planning and scoping desired capabilities for the product and completes initial cost and schedule estimates for attaining those capabilities.

C Requirements

Following the scoping phase, the project team and senior leadership develop and finalize requirements for the product. These requirements are comprised of the desired capabilities that can be developed within identified cost and schedule constraints. In essence, the company articulates the functions and features it wants the product to have, and how long it will take and how much it will cost to develop them.

D, E, F Design, Build Prototype, and Test Prototype

The project team begins developing the product design once senior leadership approves product requirements. At this point, senior leadership provides additional funding to build and test prototypes to integrate technologies, identify any design deficiencies based on tests and user feedback, and validate manufacturing processes. This design-build-test cycle repeats until the project team is satisfied the product design reflects a marketable product and is ready for manufacturing.

G Manufacturing and Shipping

After finalizing product design, leading companies survey the market to ensure that customers still want the planned product. Provided that customer demand persists, senior leadership provides additional funding to begin manufacturing and shipping. If demand has diminished, the company moves on to another effort.

H Product Support

After the product has been released to end users—either in the marketplace or shipped directly to customers—leading companies transition to providing product support to their customers. As part of this phase of development, the company solicits user feedback on the product's design and performance.

Source: GAO. | GAO-22-104513

Text of Figure 17: Leading Company Common Product Development Activities

A. Concept: Product development begins with companies exploring product concepts and selecting a product to invest in and pursue. Leading companies undertake this

exploration as part of an annual planning process with senior leadership. The process concludes with formation of a project team assigned to develop the selected concept.

B. Scoping: After completing concept development and assembling the project team, senior leadership provides limited initial funding to the project team to begin their work. Senior leadership also sets guidelines for obtaining future funding based on product development progress. The project team then begins planning and scoping desired capabilities for the product and completes initial cost and schedule estimates for attaining those capabilities.

C. Requirements: Following the scoping phase, the project team and senior leadership develop and finalize requirements for the product. These requirements are comprised of the desired capabilities that can be developed within identified cost and schedule constraints. In essence, the company articulates the functions and features it wants the product to have, and how long it will take and how much it will cost to develop them.

D, E, F: Design, Build Prototype, and Test Prototype: The project team begins developing the product design once senior leadership approves product requirements. At this point, senior leadership provides additional funding to build and test prototypes to integrate technologies, identify any design deficiencies based on tests and user feedback, and validate manufacturing processes. This design-build-test cycle repeats until the project team is satisfied the product design reflects a marketable product and is ready for manufacturing.

G. Manufacturing and Shipping: After finalizing product design, leading companies survey the market to ensure that customers still want the planned product. Provided that customer demand persists, senior leadership provides additional funding to begin manufacturing and shipping. If demand has diminished, the company moves on to another effort.

H. Product Support: After the product has been released to end users—either in the marketplace or shipped directly to customers—leading companies transition to providing product support to their customers. As part of this phase of development, the company solicits user feedback on the product's design and performance.

Source: GAO. | GAO-22-104513

Appendix VII – Comments from the Department of Defense

OFFICE OF THE UNDER SECRETARY OF DEFENSE
3000 DEFENSE PENTAGON
WASHINGTON, DC 20301-3000

ACQUISITION
AND SUSTAINMENT

February 17, 2022

Ms. Shelby Oakley
Director, Contracting and National Security Acquisitions
U.S. Government Accountability Office
441 G Street, NW
Washington, DC 20548

Dear Ms. Oakley:

This is the Department of Defense (DoD) response to the GAO Draft Report, GAO-22-104513, 'LEADING PRACTICES: Agency Acquisition Policies Could Better Implement Key Product Development Principles,' dated January 18, 2022 (GAO Code 104513).

As the report mentions, DoD has recently issued revised acquisition policy tailored for the unique characteristics of the capabilities we acquire and reflect our continued commitment to sound business principle and improved acquisition outcomes. The Department concurs with recommendations one through four of the report and will consider those principles as we update our policies.

My point of contact is Mr. Skip Hawthorne, 703-692-9556 or TW: 703-626-5604.

Sincerely,

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Christopher C. O'Donnell
Performing the Duties of Assistant Secretary of
   Defense for Acquisition

Text of Appendix VII – Comments from the Department of Defense

February 17, 2022

Ms. Shelby Oakley

Director, Contracting and National Security Acquisitions

U.S. Government Accountability Office 441 G Street, NW

Washington, DC 20548 Dear Ms. Oakley:

This is the Department of Defense (DoD) response to the GAO Draft Report, GAO-22-104513, 'LEADING PRACTICES: Agency Acquisition Policies Could Better Implement Key Product Development Principles, dated January 18, 2022 (GAO Code 104513).

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Sincerely,

Christopher C. O'Donnell

Performing the Duties of Assistant Secretary of Defense for Acquisition

Appendix VIII – Comments from the Department of Homeland Security

Homeland Security

February 18, 2022

Shelby S. Oakley
Director, Contracting and National Security Acquisitions
U.S. Government Accountability Office
441 G Street, NW
Washington, DC 20548

Re: Management Response to Draft Report GAO-22-104513, "LEADING
         PRACTICES: Agency Acquisition Policies Could Better Implement Key Product
         Development Principles"

Dear Ms. Oakley:

Thank you for the opportunity to comment on this draft report. The U.S. Department of
Homeland Security (DHS or the Department) appreciates the U.S. Government
Accountability Office's (GAO) work in planning and conducting its review and issuing
this report.

DHS leadership is pleased to note GAO's positive recognition of the Department's
significant progress in the areas of acquisition management, resource allocation, and
requirements management policies that reflect crucial portfolio management practices. In
addition, GAO acknowledged that even in the areas where they have recommendations to
improve DHS policies, the Department is already incorporating these principles and
practices through existing guides and tools.

However, DHS believes equating and comparing product development activities, such as
hardware and software design, of private, for-profit businesses with the government
acquisition policies could be confusing to some readers of GAO's report given the
government's primary mission of protecting our Nation's security, as opposed to
generating a profit. It is also important to recognize that these differing outcomes affect
incentive structures, and accordingly affect the way government does business compared
to private firms.

The draft report contained nine recommendations, including three for DHS, with which
the Department concurs. Attached is our detailed response to each recommendation.

DHS previously submitted technical comments under separate cover for GAO's consideration.

Again, thank you for the opportunity to review and comment on this draft report. Please feel free to contact me if you have any questions. We look forward to working with you again in the future.

Sincerely,

JIM H
CRUMPACKER

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JIM H. CRUMPACKER, CIA, CFE
Director
Departmental GAO-OIG Liaison Office

Attachment

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**Attachment: Management Response to Recommendations
Contained in GAO-22-104513**

GAO recommended that The Secretary of Homeland Security ensure that the DHS Under Secretary for Management update DHS acquisition policies to fully implement the following principles throughout development:

Recommendation 5: Attaining a sound business case.

Response: Concur. With regard to GAO's Principle 1 in this draft report, "Attain a sound business case that is informed by research and collaboration with customers," DHS believes existing lessons-learned processes are responsive to sub-principle 4, "preserve institutional memory and share knowledge in order to develop initial estimates, avoid earlier mistakes, and build on previous successes." The Department also agrees that a policy revision is needed to clarify the circumstances where an entire program could be terminated to be fully responsive to sub-principle 7, "willing to end product development if the product no longer has a sound business case."

More specifically, regarding sub-principle 4, DHS does not mandate creating a lesson-learned data repository for all acquisition programs to use, as the current process is effective and does not require additional resources from the Components to set up their lessons-learned repositories. Rather, the Office of Program Accountability and Risk Management (PARM) leads Department efforts to extensively share lessons-learned through various methods, such as the Component Acquisition Executive (CAE) Staff Forum, CAE Councils, and monthly CAE/PARM leadership meetings. Lessons-learned are also incorporated into policy, document templates, and handbooks/ guidebooks available to all Components in accordance with Instruction 102-01-103, Revision 01, "Systems Engineering Life Cycle", dated February 4, 2021 and PARM's "Post Implementation Review Guide," dated February25, 2020. Further, PARM will ensure that Acquisition policy and guidance continue to be readily available on the DHS Connect intranet website and updated, as appropriate.

Regarding sub-principle 7, DHS PARM will revise DHS Management Instruction 102-01-001, "Acquisition Management Instruction (Revision 1.3)," dated January 21, 2021, to include language identifying possible circumstances where an entire program may be considered for termination. However, it is important to note that DHS continuously monitors its Level 1, 2 and 3 acquisition programs to ensure approved cost and schedules are maintained, in accordance with Instruction 102-01-001, and that decisions on whether an acquisition program is ready to proceed to the next development phase are made at each acquisition decision event with senior leadership concurrence, to include the Secretary of Homeland Security, the Deputy Secretary, and the Under Secretary for Management, as appropriate. Ultimately, DHS acquisition programs are designed to

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address critical mission needs, not provide a profit, which impacts the factors considered by senior leadership when deciding whether to terminate an entire major acquisition program.

Estimated Completion Date (ECD): December 30, 2022.

Recommendation 6: Applying iterative design approaches.

Response: Concur. With regard to GAO's Principle 2 in this draft report, "Use an iterative design approach that results in minimum marketable products," and two sub-principles, DHS PARM will revise Instruction 102-01-001 to include encouraging Program Managers to use modern design tools to address sub-principle 1, "use modern design tools during both hardware and software development that enable multiple design iterations." Currently, DHS allows, but does not require, contractors developing new systems, both hardware, and software, to use modern design tools.

Regarding sub-principle 3, "use iterative design and testing to identify a minimum marketable product that can be followed by successive updates for both hardware and software development," DHS incorporated this requirement within DHS Management Instruction 102-01-004-01, "Agile Development and Delivery for IT," dated December 7, 2021 (see page 35, paragraph B, "Develop Release Roadmap"). Further, use of iterative design and testing is addressed in the current Instruction 102-01-001, "Acquisition Management Instruction (Revision 1.3)," dated January 21, 2021, for incremental development and delivery of capabilities on hardware programs. For example, instruction 102-01-001 discusses the use of segments, increments, or phases within a hardware acquisition program to ensure minimum capability is delivered in a timely manner. However, DHS PARM will revise Instruction 102-01-001 to also encourage an incremental delivery approach with hardware programs.

ECD: December 30, 2022.

Recommendation 7: Off-ramping capabilities when needed to maintain schedule.

Response: Concur. DHS Instruction 102-01-001 currently allows programs to make trade-offs between capabilities that are not tied to key performance parameters to maintain schedule. However, DHS policies do not specifically state that Components should adjust scope to stay within schedule. Accordingly, DHS PARM will revise Instruction 102-01-001 to clarify that, in addition to identifying necessary trade-offs to maintain affordability, the Component identifies trade-offs to implementing the program within the approved schedule or considering adjusting the scope.

ECD: December 30, 2022.

4

Text of Appendix VIII – Comments from the Department of Homeland Security

February 18, 2022

Shelby S. Oakley

Director, Contracting and National Security Acquisitions

U.S. Government Accountability Office 441 G Street, NW

Washington, DC 20548

Re: Management Response to Draft Report GAO-22-104513, "LEADING PRACTICES: Agency Acquisition Policies Could Better Implement Key Product Development Principles"

Dear Ms. Oakley:

Thank you for the opportunity to comment on this draft report. The U.S. Department of Homeland Security (DHS or the Department) appreciates the U.S. Government Accountability Office's (GAO) work in planning and conducting its review and issuing this report.

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However, DHS believes equating and comparing product development activities, such as hardware and software design, of private, for-profit businesses with the government acquisition policies could be confusing to some readers of GAO's report given the government's primary mission of protecting our Nation's security, as opposed to generating a profit. It is also important to recognize that these differing outcomes affect incentive structures, and accordingly affect the way government does business compared to private firms.

The draft report contained nine recommendations, including three for DHS, with which the Department concurs. Attached is our detailed response to each recommendation.

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Again, thank you for the opportunity to review and comment on this draft report. Please feel free to contact me if you have any questions. We look forward to working with you again in the future.

Sincerely,

JIM H. CRUMPACKER, CIA, CFE

Director

Departmental GAO-OIG Liaison Office

Attachment

Attachment: Management Response to Recommendations Contained in GAO-22-104513

GAO recommended that The Secretary of Homeland Security ensure that the DHS Under Secretary for Management update DHS acquisition policies to fully implement the following principles throughout development:

<u>Recommendation 5: Attaining a sound business case.</u>

Response: Concur. With regard to GAO's Principle 1 in this draft report, "Attain a sound business case that is informed by research and collaboration with customers," DHS believes existing lessons-learned processes are responsive to sub-principle 4, "preserve institutional memory and share knowledge in order to develop initial estimates, avoid earlier mistakes, and build on previous successes." The Department also agrees that a policy revision is needed to clarify the circumstances where an entire program could be terminated to be fully responsive to sub-principle 7, "willing to end product development if the product no longer has a sound business case."

More specifically, regarding sub-principle 4, DHS does not mandate creating a lesson-learned data repository for all acquisition programs to use, as the current process is effective and does not require additional resources from the Components to set up their lessons-learned repositories. Rather, the Office of Program Accountability and Risk Management (PARM) leads Department efforts to extensively share lessons-learned through various methods, such as the Component Acquisition Executive (CAE) Staff Forum, CAE Councils, and monthly CAE/PARM leadership meetings. Lessons-learned

are also incorporated into policy, document templates, and handbooks/ guidebooks available to all Components in accordance with Instruction 102-01-103, Revision 01,

"Systems Engineering Life Cycle", dated February 4, 2021 and PARM's "Post Implementation Review Guide," dated February25, 2020. Further, PARM will ensure that Acquisition policy and guidance continue to be readily available on the DHS Connect intranet website and updated, as appropriate.

Regarding sub-principle 7, DHS PARM will revise DHS Management Instruction 102- 01-001, "Acquisition Management Instruction (Revision 1.3)," dated January 21, 2021, to include language identifying possible circumstances where an entire program may be considered for termination. However, it is important to note that DHS continuously monitors its Level 1, 2 and 3 acquisition programs to ensure approved cost and schedules are maintained, in accordance with Instruction 102-01-001, and that decisions on whether an acquisition program is ready to proceed to the next development phase are made at each acquisition decision event with senior leadership concurrence, to include the Secretary of Homeland Security, the Deputy Secretary, and the Under Secretary for Management, as appropriate. Ultimately, DHS acquisition programs are designed to address critical mission needs, not provide a profit, which impacts the factors considered by senior leadership when deciding whether to terminate an entire major acquisition program.

Estimated Completion Date (ECD): December 30, 2022.

Recommendation 6: Applying iterative design approaches.

Response: Concur. With regard to GAO's Principle 2 in this draft report, "Use an iterative design approach that results in minimum marketable products," and two sub- principles, DHS PARM will revise Instruction 102-01-001 to include encouraging Program Managers to use modern design tools to address sub-principle 1, "use modern design tools during both hardware and software development that enable multiple design iterations." Currently, DHS allows, but does not require, contractors developing new systems, both hardware, and software, to use modern design tools.

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manner. However, DHS PARM will revise Instruction 102-01-001 to also encourage an incremental delivery approach with hardware programs.

ECD: December 30, 2022.

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ECD: December 30, 2022.

Appendix IX – Comments from National Aeronautics and Space Administration

Type of Correspondence Letter ▾   Center HQ ▾

National Aeronautics and Space Administration

Mary W. Jackson NASA Headquarters
Washington, DC 20546-0001

February 22, 2022

Reply to Attn of: Office of the Chief Engineer

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Letter Re

Ms. Shelby S. Oakley
Director
Contracting and National Security Acquisitions
United States Government Accountability Office
Washington, DC 20548

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Dear Ms. Oakley

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Enclosures

The National Aeronautics and Space Administration (NASA) appreciates the opportunity to review and comment on the Government Accountability Office (GAO) draft report entitled, "Leading Practices: Agency Acquisition Policies Could Better Implement Key Product Development Principles" (GAO-22-104513) dated January 18, 2022.

GAO found that the primary acquisition policies of the Department of Defense (DoD), Department of Homeland Security (DHS), and NASA implement some key product development principles but have yet to fully implement others. This gap limits agencies from ensuring a consistent approach to developing and delivering products with speed and efficiency.

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In the draft memorandum, GAO makes two recommendations addressed to the NASA Administrator to update NASA acquisition policies.

Specifically, GAO recommends the Office of the Chief Engineer (OCE) should:

Recommendation 1: The NASA Administrator should ensure the NASA OCE update NASA acquisition policies to fully implement the following principles throughout development by applying iterative design approaches.

> **Management's Response:** NASA concurs and applies a robust iterative design approach, which is an inherent part of the Agency's policy and practice. The iterative design approaches are applied to projects as appropriate to deliver a mission that balances risks to safety and mission success along with cost and schedule.

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NASA procedures and practices incorporate and implement systems that require a systematic and disciplined set of processes that are applied recursively and iteratively for the design, development, operation, maintenance, and closeout of systems throughout the life cycle of the programs and projects. This is documented as a common technical process requirement in NASA policy per NASA Procedural Requirements (NPR) 7123.1, NASA System Engineering Processes and Requirements, and further detailed in the NASA Systems Engineering Handbook.

In the report, GAO highlights that leading companies focus on designing a minimum marketable product --one with the minimum capabilities needed for customers to recognize value. In addition, in Appendix V in the section Use of Iterative Design and Testing to identify a Minimum Marketable Product, the report states that by focusing on the features that are most critical to customer needs, leading companies are able to produce new capabilities more quickly than they would be able to do if programs were bogged down with less critical requirements. While NASA finds this may be good practice for industry, the Agency operates in a high-risk environment that involves launching missions that cannot be returned and human transport to space, therefore risks must be balanced with safety and mission success.

NASA's portfolio consists primarily of unique, one-of-a-kind space flight projects that are developed, launched, and operated in a high-risk environment where safety and mission success are paramount. NASA must continuously balance all risks to deliver minimal, viable project capability while achieving safety and mission success to mitigate risk of loss to the mission. The design must meet criteria to achieve the mission safely and successfully. The project must include robust capability to meet its mission particularly in the case of the crewed missions where the design must safeguard crew, but also for robotic missions because once launched, they cannot be retrieved. They are also modified like an industry product marketed for terrestrial use.

Estimated Completion Date: Complete, iterative design approach is currently documented in policy per NPR 7123 with further detail in the companion Systems Engineering Handbook.

Recommendation 2: The NASA Administrator should ensure that the NASA OCE update NASA acquisition policies to fully implement the following principles throughout development: incorporating feedback from users of initial capabilities.

Management's Response: NASA concurs and has a policy dedicated to the collection and incorporation of feedback from users throughout the program and project life cycle, including initial capabilities. The NASA Policy Directive (NPD) 7120.6, Knowledge Policy for Programs and Projects, includes requirements

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reflecting this policy. In addition, stakeholders serve as members on Agency councils and boards, work with programs and projects day-to-day, and participate in reviews throughout the life cycle (examples and policy documentation are noted below). The information resulting from collection and review feedback is used by the program and project offices in the development and execution of programs and projects.

NASA includes mechanisms for programs and projects to obtain and utilize stakeholder or end-user feedback throughout the entire life cycle, including post mission feedback. Each Mission Directorate, Center, and program/project office are responsible for defining an approach for identifying, capturing, retaining, and acting on knowledge critical to NASA's mission, and each conducts activities or initiatives to assess and address gaps in knowledge retention and sharing. This is documented in policy NPD 7120.6, Knowledge Policy for Programs and Projects. In addition, NPR 7120.5 indicates programs and projects develop a Knowledge Management Plan that describes the strategy and processes for examining the lessons learned database for relevant lessons that can be reflected in the program/project early in the planning process to avoid known issues; identifying, capturing, and transferring knowledge; and continuously capturing and documenting lessons learned throughout the life cycle in accordance with NPD 7120.6.

NASA stakeholders are included in all reviews throughout the life cycle and provide feedback to the programs and projects assessed by the program/project office with follow-up as appropriately aligned with the feedback. Examples of stakeholders involved in the reviews include representation from across the Agency, including program/project, engineering, safety, health and medical, independent assessment team, financial, legal, astronauts, Mission Directorate Associate Administrators, Center Directors, NASA Associate Administrator, plus others. This is documented in policies, including NPD 1000.0, NPD 1000.3, NPR 7120.5, NPR 7120.8, and others.

NASA also obtains feedback from external stakeholders, examples include: NASA Federal Advisory Committee Act (FACA) committees such as the NASA Advisory Committee (NAC) and Aerospace Safety Advisory Panel (ASAP), both included as part of twelve NASA FACA bodies document in NPD 1000.3 Section 3; National Academy of Science, Industry, OMB, and Congress.

Estimated Completion Date: Complete and currently documented in several policies including, but not limited to, NPD 1000.0, NPD 1000.3, NPD 7120.6, NPR 7120.5 and NPR 7120.8.

We have reviewed the draft report for information that should not be publicly released. As a result of this review, we have not identified any information that should not be publicly released.

NASA FORM 1858 10/21 (1.15) Validate prior to use.

Once again, thank you for the opportunity to review and comment on the subject draft report. If you have any questions or require additional information regarding this response, please contact Joyce Rhym on (202) 358-1949.

Sincerely,

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Date: 2022.02.22 16:29:49
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Ralph R. Roe

Text of Appendix IX – Comments from National Aeronautics and Space Administration

Ms. Shelby S. Oakley Director

Contracting and National Security Acquisitions United States Government Accountability Office Washington, DC 20548

Dear Ms. Oakley

The National Aeronautics and Space Administration (NASA) appreciates the opportunity to review and comment on the Government Accountability Office (GAO) draft report entitled, "Leading Practices: Agency Acquisition Policies Could Better Implement Key Product Development Principles" (GAO-22-104513) dated January 18, 2022.

GAO found that the primary acquisition policies of the Department of Defense (DoD), Department of Homeland Security (DHS), and NASA implement some key product development principles but have yet to fully implement others. This gap limits agencies from ensuring a consistent approach to developing and delivering products with speed and efficiency.

In the draft memorandum, GAO makes two recommendations addressed to the NASA Administrator to update NASA acquisition policies.

Specifically, GAO recommends the Office of the Chief Engineer (OCE) should:

Recommendation 1: The NASA Administrator should ensure the NASA OCE update NASA acquisition policies to fully implement the following principles throughout development by applying iterative design approaches.

Management's Response: NASA concurs and applies a robust iterative design approach, which is an inherent part of the Agency's policy and practice. The iterative design approaches are applied to projects as appropriate to deliver a mission that balances risks to safety and mission success along with cost and schedule.

NASA procedures and practices incorporate and implement systems that require a systematic and disciplined set of processes that are applied recursively and iteratively for the design, development, operation, maintenance, and closeout of systems throughout the life cycle of the programs and projects. This is documented as a common technical process requirement in NASA policy per NASA Procedural Requirements

(NPR) 7123.1, NASA System Engineering Processes and Requirements, and further detailed in the NASA Systems Engineering Handbook.

In the report, GAO highlights that leading companies focus on designing a minimum marketable product --one with the minimum capabilities needed for customers to recognize value. In addition, in Appendix V in the section Use of Iterative Design and Testing to identify a Minimum Marketable Product, the report states that by focusing on the features that are most critical to customer needs, leading companies are able to produce new capabilities more quickly than they would be able to do if programs were bogged down with less critical requirements. While NASA finds this may be good practice for industry, the Agency operates in a high-risk environment that involves launching missions that cannot be returned and human transport to space, therefore risks must be balanced with safety and mission success.

NASA's portfolio consists primarily of unique, one-of-a-kind space flight projects that are developed, launched, and operated in a high-risk environment where safety and mission success are paramount. NASA must continuously balance all risks to deliver minimal, viable project capability while achieving safety and mission success to mitigate risk of loss to the mission. The design must meet criteria to achieve the mission safely and successfully. The project must include robust capability to meet its mission particularly in the case of the crewed missions where the design must safeguard crew, but also for robotic missions because once launched, they cannot be retrieved. They are also modified like an industry product marketed for terrestrial use.

Estimated Completion Date: Complete, iterative design approach is currently documented in policy per NPR 7123 with further detail in the companion Systems Engineering Handbook.

Recommendation 2: The NASA Administrator should ensure that the NASA OCE update NASA acquisition policies to fully implement the following principles throughout development: incorporating feedback from users of initial capabilities.

Management's Response: NASA concurs and has a policy dedicated to the collection and incorporation of feedback from users throughout the program and project life cycle, including initial capabilities. The NASA Policy Directive (NPD) 7120.6, Knowledge Policy for Programs and Projects, includes requirements reflecting this policy. In addition, stakeholders serve as members on Agency councils and boards, work with programs and projects day-to-day, and participate in reviews throughout the life cycle (examples and policy documentation are noted below). The information resulting from collection and review feedback is used by the program and project offices in the development and execution of programs and projects.

NASA includes mechanisms for programs and projects to obtain and utilize stakeholder or end-user feedback throughout the entire life cycle, including post mission feedback. Each Mission Directorate, Center, and program/project office are responsible for defining an approach for identifying, capturing, retaining, and acting on knowledge critical to NASA's mission, and each conducts activities or initiatives to assess and address gaps in knowledge retention and sharing. This is documented in policy NPD 7120.6, Knowledge Policy for Programs and Projects. In addition, NPR 7120.5 indicates programs and projects develop a Knowledge Management Plan that describes the strategy and processes for examining the lessons learned database for relevant lessons that can be reflected in the program/project early in the planning process to avoid known issues; identifying, capturing, and transferring knowledge; and continuously capturing and documenting lessons learned throughout the life cycle in accordance with NPD 7120.6.

NASA stakeholders are included in all reviews throughout the life cycle and provide feedback to the programs and projects assessed by the program/project office with follow-up as appropriately aligned with the feedback. Examples of stakeholders involved in the reviews include representation from across the Agency, including program/project, engineering, safety, health and medical, independent assessment team, financial, legal, astronauts, Mission Directorate Associate Administrators, Center Directors, NASA Associate Administrator, plus others. This is documented in policies, including NPD 1000.0, NPD 1000.3, NPR 7120.5, NPR 7120.8, and others.

NASA also obtains feedback from external stakeholders, examples include: NASA Federal Advisory Committee Act (FACA) committees such as the NASA Advisory Committee (NAC) and Aerospace Safety Advisory Panel (ASAP), both included as part of twelve NASA FACA bodies document in NPD 1000.3 Section 3; National Academy of Science, Industry, OMB, and Congress.

Estimated Completion Date: Complete and currently documented in several policies including, but not limited to, NPD 1000.0, NPD 1000.3, NPD 7120.6, NPR 7120.5 and NPR 7120.8.

We have reviewed the draft report for information that should not be publicly released. As a result of this review, we have not identified any information that should not be publicly released.

Once again, thank you for the opportunity to review and comment on the subject draft report. If you have any questions or require additional information regarding this response, please contact Joyce Rhym on (202) 358-1949.

Sincerely,

Ralph R. Roe

Appendix X – GAO Contact and Staff Acknowledgments

GAO Contact

Shelby S. Oakley, (202) 512-4841 or oakleys@gao.gov

Staff Acknowledgments

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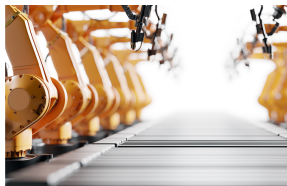
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